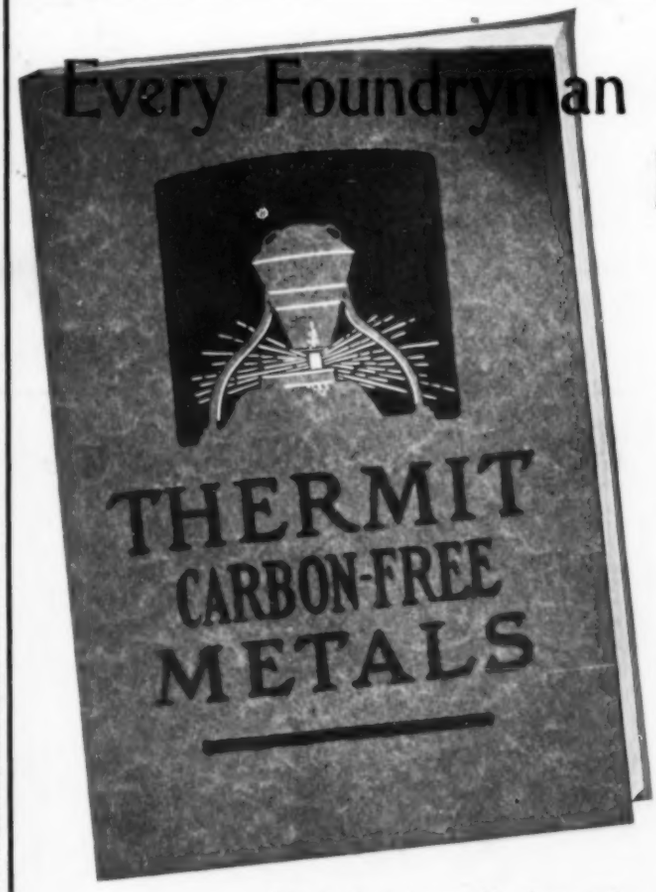
Metallurgical and Chemical Engineering

An Incorporation of

Electrochemical and Metallurgical Industry—Iron and Steel Magazine

Vol. XI. No. 6 New York, June, 1913.

25 cts. per Copy.
$2.00 per Year to U. S. and Mexico.
$2.50 per Year to other Countries.



Every Foundryman and Metallurgist Needs this book

It covers fully the production and use of carbon-free ferrous and non-ferrous Metals and Alloys. For the foundryman, the chapter on Ferro-Titanium will be of special interest and value. It tells how to treat iron and steel with carbon-free ferro-titanium and the results which will be obtained. Those troubled with porous castings or having a high percentage of defective castings will profit greatly by the information contained in this chapter alone.

Tool steels and other special alloy steels are covered in the chapter devoted to carbon-free pure chromium and ferro-chromium and their applications, which describes particularly the production of steels high in chromium and where the carbon content must be kept within specified limits.

The requirements of the brass foundry are not overlooked in this book and the various uses for pure carbonless manganese, manganese-copper, maganese-titanium and manganese-boron are treated in great detail.

The book is thoroughly illustrated and contains reports of tests and numerous formulas.

It will be sent promptly on request and is known as Pamphlet No. 2041.

Write for it today.

GOLDSCHMIDT - THERMIT CO.

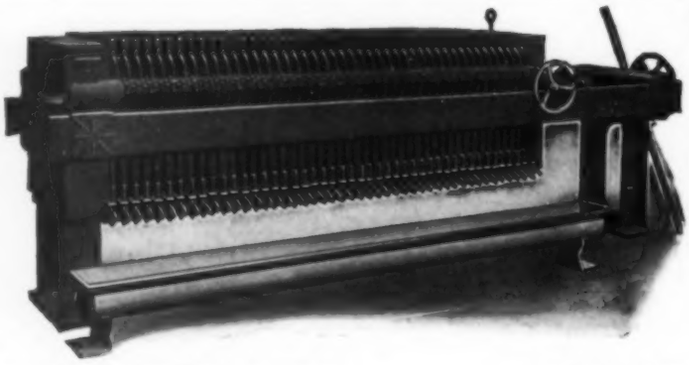
WILLIAM C. CUNTZ, General Manager

90 WEST STREET, NEW YORK

432-436 Folsom St., San Francisco. 103 Richmond St., W., Toronto, Ont.
7300 So. Chicago Ave., Chicago.

Index to Advertisers, page 73.

Classified Directory, pages, 66-67-68



The Widening of the Joint Surfaces

on the plates and frames of

Shriver's Filter Presses

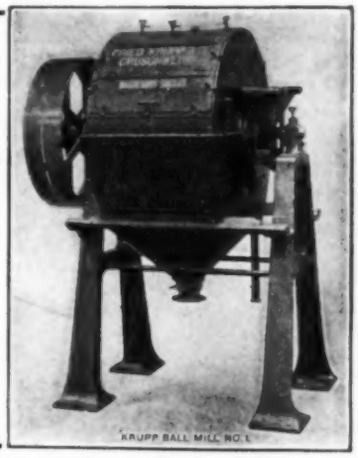
together with the accurately machined castings, the duplicate parts, counterbalanced thrust block and other features—and the PROMPT DELIVERY WE GUARANTEE, owing to our doubled facilities, make them the presses you cannot overlook. All sizes and designs. Small presses for laboratory work.

T. SHRIVER & CO. Office and Works 808 Hamilton Street **HARRISON, N. J.**

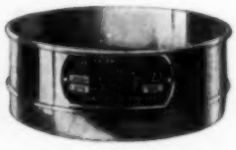
Krupp Machinery and Products

BALL MILLS EXCELSIOR MILLS
TUBE MILLS RESISTANCE WIRE
FORGINGS OF ALL QUALITIES OF STEEL
SPECIAL MACHINERY OF ALL CLASSES

THOS. PROSSER & SON, 22 Platt Street, New York



THE TYLER STANDARD SCREEN SCALE SIEVES



THE Tyler Standard Screen Scale Sieves have been constructed from wire cloth, specially prepared, with accurately measured openings that increase and decrease throughout the series in a fixed ratio.

The Screen Scale has as its base an opening of .0029 which is the opening in 200 mesh .0021 wire—the standard sieve as adopted by the Bureau of Standards.

The diameter of the openings as shown in the table increase in the Rittinger ratio of the square root of 2 or 1.414, making the area of each sieve in the scale just double that of the next finer or half that of the next coarser.

The Tyler Standard Screen Scale Sieves divide the tested product in much better proportion than a Sieve series with no relationship between the openings.

Specially ruled paper is furnished in connection with the Sieves for making either a cumulative direct plot or a cumulative logarithmic plot showing a graphic illustration of screen analysis.

The new Testing Sieve catalogue (just issued) describes fully the Screen Scale Sieve and the method of plotting curves and will be sent on request.

Write for Testing Sieve Catalogue No. 36 "B" and discounts

TYLER STANDARD SCREEN SCALE

RATIO √2 OR 1.414			
Opening in Inches	Opening in Millimeters	Mesh	Diam. Wire, Dec. of an Inch
1.050	26.67		.149
.742	18.85		.135
.525	13.33		.105
.371	9.423		.092
.263	6.680	3	.070
.185	4.699	4	.065
.131	3.327	6	.036
.093	2.362	8	.032
.065	1.651	10	.035
.046	1.168	14	.025
.0328	.833	20	.0172
.0232	.589	28	.0125
.0164	.417	35	.0122
.0116	.295	48	.0092
.0082	.208	65	.0072
.0058	.147	100	.0042
.0041	.104	150	.0026
.0029	.074	200	.0021

The W. S. Tyler Company :: Cleveland, Ohio

MANUFACTURERS OF WIRE CLOTH AND MINING SCREEN

METALLURGICAL & CHEMICAL ENGINEERING

ISSUE OF JUNE, 1913

Award of the Willard Gibbs Medal to Dr. Leo H. Baekeland 311
A report of the proceedings at the recent presentation of the third Willard Gibbs medal to Dr. L. H. Baekeland, in Chicago, with abstracts of the principal speeches made and an abstract of the address of Dr. Baekeland on the Chemical Constitution of Resinous Phenolic Condensation Products.

Evolution of Methods of Handling Slime. By H. N. Spicer..... 315
The third article of the serial in which the author, who is an authority on slime treatment, gives a critical account of the evolution of methods of handling slime in different countries, based on his observations on a recent trip around the world. The present instalment deals with methods in use in Australia, with special reference to Broken Hill and Kalgoorlie practice.

Electrode Holder Construction for Electric Furnaces..... 321
A long and profusely illustrated article showing the different designs of top-holders and side-holders for electrodes in use in European electric furnace plants, with additional notes on the joining and dimensioning of electrodes.

Copper Smelting Operations of the Santa Fé Gold and Copper Mining Co. By Clarence T. Emrich... 327
An illustrated article giving details of the power plant, methods of sorting, sampling, and analyzing the ore, and discussing the good results obtained with a somewhat obsolete type of furnace. The improvements obtained by water-cooling the jackets are stated in detail.

Note on Cold-Junction Corrections for Thermocouples. By Paul D. Foote..... 329
A critical discussion of methods for correcting or compensating the cold-junction error in the use of thermocouples. This subject is of importance for thermoelectric pyrometry.

Heat Transmission and Entrainment in Vacuum Evaporators. By E. W. Kerr..... 333
An account of an elaborate series of tests in which the effect of various items on heat transmission was analyzed, such as the effect of varying the head of the juice, the effect of temperature levels, the effect of air in the heating steam used, the effect of density of steam and of density of boiling water, effect of superheat, and the value of the downtake. Finally an account of special entrainment tests is given.

EDITORIAL:
- The Willard Gibbs Medal..... 302
- Zinc Dust Precipitation..... 304
- The Detailed Pig-Iron Statistics..... 305
- Shape and Rod Production..... 305

READERS' VIEWS AND COMMENTS:
- New York Hydroelectric Development. By F. A. Lidbury 306
- The Thermist. By Albert Sauveur..... 306
- Simple Rules for Temperature Conversion. By Donald M. Liddell..... 306
- Inverse Weighing of Light Objects on Heavy Weight Scales. By Wallace B. Crowe..... 306
- The Effect of Power Development on the Canadian Falls at Niagara. By P. McN. Bennie..... 307

Iron and Steel Market..... 307
The Non-Ferrous Metal Market..... 308
The Western Metallurgical Field..... 309
Boston Meeting of the American Institute of Chemical Engineers 310
International Engineering Congress..... 310
The Chemistry of Tungsten. By Chas. Baskerville..... 319
Notes on Chemistry and Metallurgy in Great Britain.. 342
Methods for Investigating and Recording Atmospheric Impurities, Including the Soot and Dust Suspended in the Atmosphere. By John B. G. Kershaw..... 339
Recent Chemical and Metallurgical Patents..... 343
Synopsis of Recent Chemical and Metallurgical Literature 348
Refractories Manufacturers' Association..... 350
The Production of Sound Steel Ingots..... 351
Iron and Steel Committee of the American Inst. of Mining Engineers..... 354
A New Recorder Pen Arm to Facilitate the Changing of Charts 355
A New Ammeter and Voltmeter..... 355
Concentration Low Grade Iron Ores in Michigan.... 357
The Design, Construction and Uses of Centrifugals. By H. H. Stephens..... 358
Absorption and Reaction Towers for Chemical Factories 359
Production of the Diamond in Electric Furnaces. By Francis P. Mann..... 361
Refuse Destructor Test..... 363
Personal 363
Digest of Electrochemical U. S. Patents..... 364
Book Reviews..... 365

Published by
McGRAW PUBLISHING CO., Inc., 239 West 39th Street, New York

The Only Natural Alloy of Nickel and Copper is

MONEL METAL

This new material, used with such success by metallurgical and chemical engineers to withstand strong acid and alkaline conditions, can now be obtained promptly in any form from our complete stock.

Monel Metal is sixty-eight per cent nickel, twenty-seven per cent copper and the balance iron and manganese.

It has proved invaluable because, although light and easily worked, it has a tensile strength of 75,000 to 100,000 lbs. per square inch, is acid resisting to a remarkable degree and most economical.

While Monel Metal in rods, castings and sheets is adaptable practically everywhere that machinery is used, its resistance to acid, alkaline and weather conditions makes it peculiarly valuable for smelter roofs, pump rods, mine screens, superheated steam valves, pickling frames and roofing of all kinds.

"The Biddle Bulletin," a publication devoted to the uses and money-saving ability of Monel Metal, is now circulating monthly among 3,000 manufacturers, mine owners and industrial men of all kinds. A business card or a request on your letter head will put you on the mailing list.

Remember that we carry Monel Metal in stock and can fill your orders promptly or make up castings from your patterns.

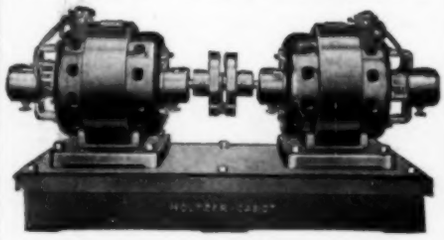
Biddle Hardware Company
DISTRIBUTORS
Established 1837
512 Commerce Street Philadelphia
150 Chambers Street, New York
Branch Offices
London Montreal Stockholm Buffalo

ANY KIND OF CURRENT

Will Operate or may be obtained from

HOLTZER-CABOT

Motor Generators



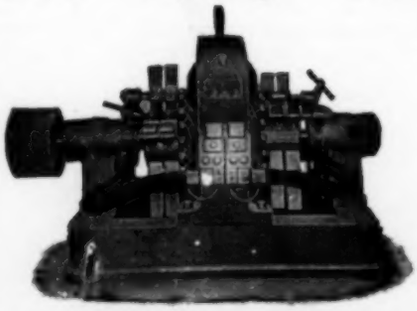
You cannot fail to appreciate the advantage of having the apparatus you buy specially designed to meet your individual requirements.

Write for Bulletin No. 302

HOLTZER-CABOT ELECTRIC CO.
BOSTON CHICAGO

Low Voltage Generators

Up to 10,000 amperes



Single, two and three voltages for School and Laboratory work. Deposition, Refining and Separation of metals.

Chas. J. Bogue Electric Co.
513-515 West 29th, New York

ELECTROLYTIC LEAD REFINING

as adopted at Trail, B. C.; Chicago, Ill. and Newcastle-on-Tyne, England.

For Licenses in the United States, England, Germany, Australia and Mexico, address

ANSON G. BETTS, 16th Street North, Troy, N. Y.

Metallurgical and Chemical Engineering

A Consolidation of Electrochemical and Metallurgical Industry and Iron and Steel Magazine.

Vol. XI | New York, June, 1913 | No. 6

PUBLISHED MONTHLY BY THE
McGraw Publishing Company, Inc.
James H. McGraw, President.
C. E. Whittlesey, Secretary and Treasurer.
239 West 39th Street, New York.
Telephone Call, 4700 Bryant. Cable Address, Metchem, New York.

Western Office.....421 Boston Bldg., Denver, Colo.
Chicago Office.....Old Colony Building
Philadelphia Office.....Real Estate Trust Building
London Office.....Hastings House, Norfolk St., Strand

E. F. Roeber, Ph.D., Editor.
H. C. Parmelee, Western Editor.

J. M. Muir, Manager.

Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50. (European exchange, 10 shillings, 10 marks, 12.50 francs.)

Copyright, 1913, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

New York, June, 1913.

CONTENTS.

Editorial:
The Willard Gibbs Medal..... 303
Zinc Dust Precipitation..... 304
The Detailed Pig-Iron Statistics..... 305
Shape & Rod Production..... 305
Readers' Views and Comments:
New York Hydroelectric Development. By F. A. Lidbury..... 306
The Thermist. By Albert Sauveur..... 306
Simple Rules for Temperature Conversion. By Donald M. Liddell 306
Inverse Weighing of Light Objects on Heavy Weight Scales. By Wallace B. Crowe..... 306
The Effect of Power Development on the Canadian Falls at Niagara. By P. McN. Bennie..... 307
Iron and Steel Market..... 307
The Non-Ferrous Metal Market..... 308
The Western Metallurgical Field..... 309
Boston Meeting of the American Institute of Chemical Engineers.... 310
International Engineering Congress..... 310
Award of the Willard Gibbs Medal to Dr. Leo H. Baekeland..... 311
Evolution of Methods of Handling Slime—III. By H. N. Spicer..... 315
The Chemistry of Tungsten. By Chas. Baskerville..... 319
Electrode Holder Design for Electric Furnaces..... 321
Copper Smelting Operations of the Sante Fe Gold & Copper Mining Co. By Clarence T. Emrich..... 327
Note on Cold-Junction Corrections for Thermocouples. By Paul D. Foote..... 329
Heat Transmission and Entrainment in Vacuum Evaporators. By E. W. Kerr..... 333
Methods for Investigating and Recording Atmospheric Impurities, Including the Soot and Dust Suspended in the Atmosphere. By John B. C. Kershaw..... 339
Notes on Chemistry and Metallurgy in Great Britain..... 342
Recent Chemical and Metallurgical Patents..... 343
Synopsis of Recent Chemical and Metallurgical Literature..... 348
Refractories Manufacturers' Association..... 350
The Production of Sound Steel Ingots..... 351
Iron and Steel Committee of the American Institute of Mining Engineers..... 354
A New Recorder Pen Arm to Facilitate the Changing of Charts..... 355
A New Ammeter and Voltmeter..... 355
Concentration Low-Grade Iron Ores in Michigan..... 357
The Design, Construction and Uses of Centrifugals. By H. H. Stephens..... 358
Absorption and Reaction Towers for Chemical Factories..... 359
Production of the Diamond in Electric Furnaces. By Francis P. Mann..... 361
Refuse Destructor Test..... 363
Personal..... 363
Digest of Electrochemical U. S. Patents..... 364
Book Reviews..... 365

The Willard Gibbs Medal

The report of the presentation of the third Willard Gibbs Medal to Dr. Leo H. Baekeland, which is published elsewhere in this issue, suggests a brief comment on medals in general and on the Willard Gibbs medal and its present recipient in particular.

There are medals and medals. Their variety is unlimited whether we consider them as pure works of art or as standing for a purpose. From a purely artistic viewpoint the renaissance of the medal has been one of the phenomena of art evolution during, say, the last forty years, and a study of modern medals may be made a most interesting source of instruction, as it will reveal some principal leitmotivs in the evolution of art of different nationalities and different schools.

But medals are far more important by what they stand for. And in this respect the modern renaissance of the medal is due to the complete change in public sentiment from exclusive war-hero worship to a broad recognition that honor is due even more forcibly to those who have accomplished works of peace and contributed to the positive progress of human civilization. This country has the Civil War Medal, the Indian War Medal, the War With Spain Medal, and so on. But it has now also a series of medals, founded in recent years by scientific and engineering societies, such as the Edison Medal, the John Fritz Medal, the Willard Gibbs Medal, and the Perkin Medal. And if the competition between different societies in founding new medals seems at times almost to degenerate into a fad or a craze, it still emphasizes the healthy psychological attitude that is at the bottom.

We could easily add to the list of prominent medals conferred for engineering or scientific attainments. But those we mentioned—the Edison, John Fritz, Willard Gibbs, and Perkin medals—emphasize by their very names one and perhaps the most prominent function which these medals have to fulfill—to link together the name of the man in whose honor the medal was founded with the name of the recipient of the medal, to link together the past with the present and the future, or in a single word to give inspiration.

To make our point clear with especial reference to the Willard Gibbs medal and its award to Dr. Baekeland, we may refer to the words of Dr. Richardson in his happy presentation speech. "The man who accepts a medal takes upon himself a heavy responsibility. Like the man in the story he places himself in the hands of his friends in a most absolute way. There is no relief or rest for him from the time he arrives in town until he is safely aboard a train and on his way home. There is every likelihood of his being over-entertained and over-feasted. . . ." All this is very true, but the concluding sentences would seem to over-

shadow a deeper meaning intended, we think, in the first sentence quoted.

Willard Gibbs died ten years ago and Dr. Wilder D. Bancroft in the obituary written for this journal (Vol. 1, page 313) made some pointed and impressive remarks which are fundamentally as true to-day as they were ten years ago and which we quote because they came back at once to our memory in connection with the sentences of Dr. Richardson given above. With respect to Gibbs' Equilibrium of Heterogeneous Substances Dr. Bancroft wrote:

"While the fundamental importance of this paper is now generally recognized by chemists, it must be admitted that this is very largely lip service still. There is no man who pretends to understand Gibbs. There are some who have understood small portions of this classical work, but that is all. As one distinguished scientific man has said, it is easier to discover a thing oneself than to find it in Gibbs. This is perfectly true. But when one has, after much effort, discovered a thing, one finds it all in a more general form in Gibbs. The trouble is not that Gibbs is obscure. After one has mastered a small portion, one wonders that there ever should have been any difficulty in understanding that particular passage. But the difficulty reappears with the next passage. Gibbs' mind works along different lines from those of the chemist of to-day and the latter cannot follow. We all know that Faraday's reasoning seemed obscure until Clerk-Maxwell put it into mathematical form. When some experimental chemist succeeds in doing for Gibbs' mathematics what Clerk-Maxwell did for Faraday's experiments, then for the first time shall we appreciate the real greatness of the man whose loss we mourn."

We need hardly draw, in many words, the logical conclusion from our connection of these sentences with the presentation of the Willard Gibbs Medal to Dr. Baekeland. We do not know anyone in the world who by ability, enthusiasm, and perseverance would be more predestined to do for Gibbs' mathematics what Clerk-Maxwell did for Faraday's experiments, than Dr. Baekeland. Will he do it? We should not wonder.

Zinc-Dust Precipitation

The continued and increasing use of zinc dust as a precipitant for gold solutions in the cyanide industry is gradually extending our practical knowledge of the operation, even though all the chemistry involved may not be definitely known. As in the development of any novel process the original advocates of zinc dust precipitation hedged the method about with certain precautions and restrictions which were dictated by their best judgment and reason. But likewise, as in the further application of such novel processes, the actual use of zinc dust in the hands of various metallurgists and under a variety of conditions has gradually altered the original practice. Step by step some of the negative precautions have been disregarded with apparent impunity, while at the same time the original positive instructions have been altered with consequent improvement. Thus, both by accident and design, fallacies have been exposed and our practical knowledge increased.

It will be recalled that one of the points strongly emphasized in the early literature on zinc-dust precipitation was the necessity of preventing oxidation of the dust prior to its mixture with the gold solution. The idea was strongly held that efficient precipitation would occur only when the dust particles were fresh and uncontaminated by oxidation products. In fact, small tube mills were used to brighten the zinc just before using and successive charges of dust were constantly undergoing this treatment in order that fresh material might be available for precipitation

This feature was embodied in patents granted to one metallurgist, who proposed to use a tube mill or other grinding apparatus in the precipitation circuit so that the mixture of dust and solution should pass through it. This procedure was adopted because such precipitants as zinc dust "are rendered less efficient and active by reason of the presence of a deterrent coating upon the surfaces of the particles thereof, caused in part at least by their well-known property of oxidation." The mechanical removal of the coating of oxide by abrasion was regarded as essential to efficient precipitation, because otherwise it must be removed by solution before good contact could be obtained.

It has come about, however, in at least one instance that the protection of zinc dust against oxidation by exposure to air is wholly disregarded. At the Homestake slime plant where zinc-dust precipitation was first installed on a large scale the dust is exposed to air in shallow pans for periods ranging from several days to a week or more. No provision is made for subsequently grinding the dust to remove any coating of oxide that may have formed, and it is fed dry to the gold solution and pumped to the press. Nor have any ill effects followed this disregard of a generally accepted precaution, all of which suggests the probable fallacy of the original idea.

Another feature of zinc-dust precipitation, which was early adopted and later abandoned, was the practice of forming an emulsion of dust and solution which was then added to the main body of the latter and pumped to the presses. The method usually adopted for forming the emulsion was to mix zinc dust with a small stream of barren solution in an inverted cone and to agitate the mixture by a jet of air. The emulsion overflowed from the cone and joined the gold solution on its way to the press. An investigation into this method of precipitation made some time ago by Mr. A. J. Clark, metallurgist for the Homestake company, led to the condemnation of air agitation in connection with gold solutions prior to precipitation. The reaction of the carbon dioxide of the air with the lime dissolved in the solution, formed calcium carbonate which was found to exercise a genuine deterrent effect on precipitation by coating the zinc particles and preventing contact with the solution. On the removal of the air-agitated mixing cones and the substitution of dry feeding direct to the precipitation line the troubles due to lime coating disappeared.

The ill effects of calcium carbonate as first determined at the Homestake are now generally recognized and the emulsifying cone with its air agitation is no longer in general use. The original theory seems to be well founded and has not been changed. On the other hand, the exposure of zinc dust to the air before using is not yet generally practiced, but it may be only a short time until the old opinion on this point may be broadly regarded as a fallacy.

The Detailed Pig-Iron Statistics

Supplementary to the general pig-iron statistics for 1912, issued Jan. 30 by the Bureau of Statistics of the American Iron and Steel Institute, a detailed statement is made under date of May 15, showing the distribution as to grade and also the distribution as to condition in which used, the latter being a very commendable and interesting improvement over the presentation of previous years.

A slight correction (involving about 1,000 tons) is made to the total pig-iron production of 1912, placing the figure at 29,726,937 gross tons, against 23,649,547 tons in 1911 and 27,303,567 tons in 1910, the best previous record for a calendar year. Each year one likes to test the old trade dictum that pig-iron production doubles every decade, hence we observe that the 1912 production is 1.67 times the best production made through 1902, 3.24 times the best production made through 1892 and 6.42 times the best production made through 1882. The rule of doubling held good through 1902, but has not held good through 1912. The rule easily held good through 1906 but has since broken down and cannot be reinstated except by extraordinary gains in future.

The statistics of production by grades shows a continuance of the change shown in recent years, that the production of foundry grades does not increase as rapidly as the production of steel-making grades. Despite the large gain in total pig-iron production in 1912 the production of foundry and ferro-silicon, 5,073,873 tons, was less than the corresponding production in 1907, 1909 and 1910. This is a part of the natural evolution whereby if rolled steel does not actually supplant cast iron it at least enjoys by far the major part of the increased demand as the general use of ferrous products increases.

The production of Bessemer and low-phosphorus iron was 11,664,015 tons against an output of 11,417,886 tons of basic iron. The small difference was probably exceeded by the production of low-phosphorus iron—limited to 0.04 per cent in phosphorus—leaving it that the production of Bessemer iron—limited to 0.10 per cent in phosphorus and invariably made very close to that limit—fell slightly below that of basic iron, whereas ten years earlier 5 tons of Bessemer iron were made to 1 of basic. The maximum production of Bessemer and low-phosphorus iron occurred in 1906, with 13,840,518 tons, and obviously in the present order of things that tonnage will stand as record.

The condition in which iron was delivered for consumption is reported for the first time, the figures for 1912 being as follows:

Molten	16,466,722
Sand cast	6,309,495
Machine cast	6,214,121
Chill cast	726,017
Direct castings	10,582
Total	29,726,937

To the blast-furnace manager it may be interesting to note that 726,017 tons were "chill cast," which we understand to mean simply that the chills were placed by hand and were not in a casting machine, representing probably a limited demand for chill-cast iron from furnaces which have not found it desirable to install machines. The metallurgist will simply add the "machine cast" to the "chill cast" finding that 6,940,138 tons were cast in chills. It would have made the statistics more interesting to report how much of each grade was delivered in the different forms, but one can make fairly close surmises. We know that all the basic iron was either molten or chill cast, and that very little Bessemer is sand cast, most of it being used molten and a comparison of figures indicates that nearly all the foundry and malleable iron was sand cast. In other words, the foundries have not taken to chill-cast iron as it was thought a dozen years ago they might.

The molten-iron deliveries of 16,466,722 tons were exclusively to the Bessemer converter and the open-hearth steel furnace, outside of a limited tonnage delivered for the direct casting of ingot molds, whereby it may be taken that 16,000,000 tons of Bessemer and basic iron were used for steel making out of a total production of about 23,000,000 tons. The steel mills which regularly practice the direct metal process must necessarily use some cold iron, including "Sunday metal," iron shipped from detached furnaces, broken molds, etc., so that their proportion is more than three-fourths of the total steel industry and may easily be more than four-fifths.

This represents a rapid growth in a relatively easily practiced economy.

Shape and Rod Production

Production statistics of the American iron and steel trade make their appearance in rather irregular order. Thus early in the year the rail production of 1912 was reported, while in the past fortnight the statistics of rods and structural shapes have been returned but no statistics have yet appeared of steel ingots.

Rails were reported at 3,327,915 gross tons, a gain of 18 per cent over 1911, but a loss of 16 per cent from the record year of 1906; rods are reported at 2,653,553 tons, a gain of 8 per cent over 1911, which furnished the record, while structural shapes are reported at 2,846,487 tons, a gain of 48 per cent over 1911 and of 25 per cent over 1909, the previous record year. Thus outputs in the different finished products do not hold well together at all. The different products contribute quite different proportions to the total in different years. Were it the case that rails, rods and shapes furnished the same proportion in 1912 as in 1911, three-eighths, the total output of rolled iron and steel in 1912 would prove to be about 23,400,000 gross tons, against a record output of 21,621,279 tons in 1910 (of which 1,740,156 tons was rolled iron) but we expect the 1912 total when finally reported to be considerably larger than this conventional amount.

The structural shape production in 1912 was extremely heavy as compared with previous years, when it is considered that the year was not regarded as one of exceptional activity in the erection of large bridges and buildings. In 1906, on the other hand, there was a great deal of such work, yet the 1912 tonnage exceeds that of 1906 by 34 per cent. From 1892, the first year of structural shape statistics, to 1912 there is an increase of 525 per cent; the tonnage was more than sextupled.

Readers' Views and Comments

New York Hydroelectric Development

To the Editor of Metallurgical and Chemical Engineering:

Sir:—There is no doubt that a public service of the first magnitude can be rendered by the engineering press in pointing out the ill-considered nature of the present proposals for the operation of power plants by the State of New York. The consummation of these schemes can only result in a reduced price of power at the cost of the taxpayers of the State as a whole. To Mr. Reginald Pelham Bolton much credit is due for his thorough, albeit somewhat one-sided and prejudiced exposure, in his recent book entitled "An Expensive Experiment" and reviewed in your last issue (p. 302), of the actual results of the operation of similar schemes in the Province of Ontario.

It is not clear, however, what good purpose can be served by such "economic" arguments as that contained in Mr. Bolton's letter to the *Electrical World* of April 12 to the effect that in the case of Niagara Falls "the financial benefits derived from the vast number of visitors who bring to the channels of general trade, as reported by the Committee of Engineers appointed by the United States Government, an annual revenue exceeding $20,000,000" are far greater than the value of the power that could be obtained by a more complete utilization of the Falls.

This argument is either unintelligent or insincere; its logical strength can be shown by the *reductio ad absurdum* that, if the economic value of anything is to be measured by its power of inducing unproductive expenditure, we shall have to conclude that prostitution is one of the greatest commercial assets of New York State!

Nor are Mr. Bolton's estimates of the economic value of Niagara power more reliable than his economic logic. Its value is only to be measured by a realization of what the products of the enormous group of electrochemical industries, which have sprung up at Niagara Falls as a direct result of the power development and which constitute a most efficient consumptive outlet for the bulk of the power, have done for the advance of industry in general. Possibly Mr. Bolton has no such realization; and if this is so, I shall be glad, if he will call upon me when his investigating journeys next bring him to this neighborhood, to see that he gets from men connected with these industries some idea of their enormous and far-reaching economic importance. It will further be demonstrated to him by the historic method (this ought to appeal to him particularly) that without the development of Niagara power the development of these industries would have been set back ten years, if indeed it would have been at all possible.

The trouble with Mr. Bolton is that he is partly an engineer and partly a "trustee of the American Scenic and Historic Preservation Society." Niagara Falls is his "King Charles' Head." Pending his receipt of instruction on the points mentioned above, let him bury it, if possible, when discussing subjects to which it has no relation.

F. Austin Lidbury.

Niagara Falls, N. Y.

The "Thermist"

To the Editor of Metallurgical and Chemical Engineering:

Sir: I note with interest in your May, 1913, issue Mr. H. M. Boylston's suggestion to call "thermist" the technical specialist in charge of the heat treatment of metals in industrial plants. The recommendation seems a happy one to me. The term is short and suggestive and infinitely superior to such periphrasis as the metallurgist, or metallographist, or metallurgical engineer, or chemist, or engineer of test "in charge of heat treatment."

There certainly is a growing need and demand for engineers and metallurgists possessing an expert knowledge of the heat treatment of metals and especially of iron and steel and capable of applying theoretical principles in a practical and effective manner to the daily commercial production of finished or semi-finished articles. And may I not seize this opportunity to express a thought that has come to my mind more than once, namely, that technical schools teaching metallurgy should recognize the need and demand to which I have just referred by providing in their last year's curriculum special and practical laboratory courses in metallurgical pyrometry and heat treatment of metals, subjects which are at present but scantly treated?

Harvard University. Albert Sauveur.

Simple Rules for Temperature Conversion

To the Editor of Metallurgical and Chemical Engineering:

The methods given by Mr. Childs for temperature conversion in your May issue (page 230) seem of dubious value. Reduced to formulas they are:

$$(F + 40)\frac{5}{9} - 40 = C.$$

$$(C + 40)\frac{9}{5} - 40 = F.$$

The old rule seems simpler.

$$(F - 32)\frac{5}{9} = C.$$

$$\frac{9}{5}C + 32 = F.$$

In view of the enormous waste of brain tissue going on in evolving "long cuts" and approximations for metric conversion allow me to suggest a rule I have found most satisfactory for all such work: Learn the correct formula and use it.

Donald M. Liddell.

Elizabeth, N. J.

Inverse Weighing of Light Objects on Heavy Weight Scales

To the Editor of Metallurgical and Chemical Engineering:

Sir:—It oftens happens that one desires to weigh with moderate accuracy a small object, when only scales for heavy weighing are available. On such an occasion the writer conceived the following method of accurate weighing, which may prove useful to others.

The principle involved is based upon the simple relation of the beam weight to the platform weight, which in the scales used was one to one hundred, i.e., 1 lb. attached to the suspended beam weight was just equipoised by 100 lb. on the platform. Having adjusted the empty scales to equilibrium, object (X) to be weighed was then attached to suspended beam weight, and any convenient material (M) was placed on platform until scales were again in equilibrium. Object (X) was then removed from beam, and the weight of the material (M) determined as usual. Then the weight of the material (M), divided by 100 equaled the weight of the object (X).

The beam being graduated to and sensitive to 0.25 lb., made the scale sensitive to 0.04 oz. by this inverse method of weighing.

Wallace B. Crowe.

Homestead Steel Works,
Munhall, Pa.

Effect of Power Development on the Canadian Falls at Niagara

To the Editor of Metallurgical and Chemical Engineering:

Sir: Facing page 64 of Mr. Reginald Pelham Bolton's book entitled "An Expensive Experiment," and reviewed on page 302 of your May issue, is a photograph with this legend:

"The Effect, in Part, of the Expensive Experiment on the Canadian Falls." (This picture is reproduced herewith as Fig. 1.)

The implication is that the rather small amount of water flowing over the portion of the Falls shown is due to the power development. In order to make this evidence conclusive it is, of course, necessary to make a comparison with a photograph taken before the power development.

On the title page of Mr. Bolton's book is a list of various societies of which he is a member, the character of which would indicate that he is a man of strict mental probity and scientific attainment. The first quality would exclude the possibility of his having deliberately used a misleading photograph; the second excludes that he should have failed to make the necessary comparison.

I send you herewith a photograph showing the same portion of the Goat Island end of the Canadian Falls. (This is reproduced in Fig. 2.) In Mr. Bolton's illustration (Fig. 1) may be plainly seen a portion of the intake of the Ontario Power Company, thus establishing the date of the photograph as *after* that power installation, while in the photograph I send (Fig. 2) this feature is missing, thus establishing its date as *before* the power installation. This may well be, since the photograph I send is from a well authenticated negative by Nielson, at least 20 years old.

It will now be interesting to see upon which horn of the dilemma Mr. Bolton chooses to impale himself.

P. McN. BENNIE.
Fitzgerald and Bennie Laboratories, Niagara Falls, New York.

FIG. 1.—GOAT ISLAND END OF CANADIAN FALLS AFTER POWER DEVELOPMENT
(Reproduced by Photography from Mr. Bolton's Book)

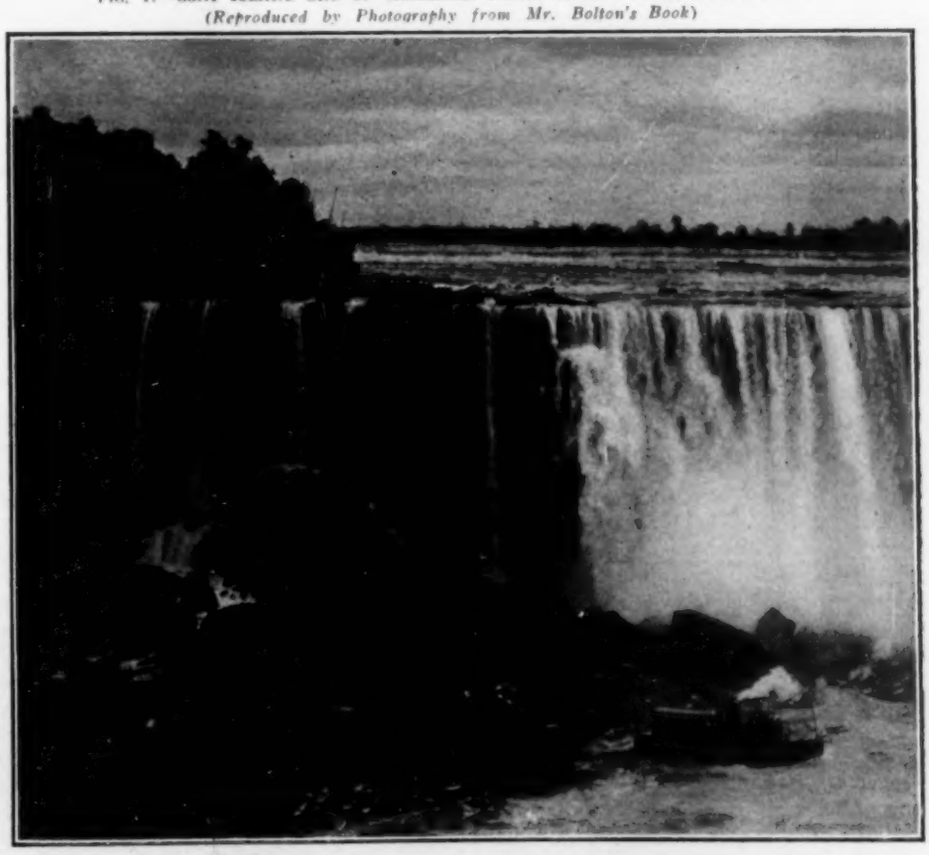


FIG. 2.—OLD PHOTOGRAPH TAKEN BEFORE POWER DEVELOPMENT

The Chapman Engineering Company, Mt. Vernon, Ohio, report considerable activity in the gas producer field. Among the recent sales of their standard 10-ft. producers are six for the Forged Steel Wheel Company, Butler, Pa., two for the Railway Steel Spring Company, Inter-Ocean Works, Chicago Heights, Ill., one for the Carnegie Steel Company, Mingo Works, Mingo Junction, O., two for the Nova Scotia Steel & Coal Company, Sydney Mines, Nova Scotia. The Bethlehem Steel Company, South Bethlehem, Pa., ordered six more Chapman producers for open-hearth work.

Iron and Steel Market

New buying of pig iron and steel products came to almost a complete stop in May, while buyers continued to take full pig-iron shipments on old purchases, and in finished steel products specifications continued at a fair rate, averaging 60 to 75 per cent. of the current shipments.

Almost all the mills had accumulations of specifications for finished steel products, some of the accumulations being quite large, and as a consequence some mills can stand the reduced rate of specifying much better than others. There is disclosed a striking difference between the position of different mills.

which seems clearly ascribable to the difference in sales policies last autumn. At that time, when the general buying movement was in progress, some mills quoted slightly lower prices than others, but were very particular as to the character of business booked. Others were stiff in their views as to prices but very accommodating as to the kind of contract they would write. Had demand continued extremely good, the latter would have fared the better, but as it is the more conservative and painstaking mills have occasion to reflect upon the truth of the adage referring to the relative desirability of a bird in the hand as against two in the bush.

Production throughout the iron and steel industry has been maintained at the full rate, involving practically record production and shipments. According to all the evidence there is no accumulation of finished product in the hands of buyers, and apparently therefore the experience of 1910 is not being repeated, when buyers received material simply because it was cheap. It is barely possible, however, that such judgment is premature. There is undoubtedly much low-priced material still being delivered.

The future of the market is altogether in doubt, and particularly so when it is observed that there is the widest divergence in the views expressed in the trade as to when improvement is to be expected. The least hopeful view expressed is that next year as a whole will be a poor one, there being no opinion expressed that a period of years will elapse before recent favorable conditions are duplicated. In some quarters an improvement in the early autumn seems to be expected. While no predictions are made, it is probably generally believed, even by producers themselves, that another upturn cannot occur without a decline in prices first furnishing the foundation.

Pig Iron

The decline in pig iron prices has been proceeding at a more rapid rate than in the early months of the year, prices having started to yield fractionally toward the close of December. Averaging all grades, the rate of decline since early in April has been about 75 cents per ton per month, against a rate one-third or one-half as great in the first quarter of the year. The decline has been fairly uniform geographically, but not so as to grades, since foundry iron has declined considerably more than steel making grades, Bessemer and basic. The latter have not been supported by market purchases to any extent, but are supported in great measure by the heavy deliveries on what are practically requirement contracts, such contracts being entered into for an extended period, the furnace to keep the buyer supplied and the iron to be settled monthly according to the disclosed market price for the month. Foundry iron buyers are fairly well covered to July 1, few contracts running beyond that date, while in quite a number of instances deliveries have been anticipated so that contracts will be filled before July 1. Buyers are all holding off until the last moment, but an active point must be reached soon, probably before the end of June, with prices continually declining and consumers reaching the end of their supplies. The market is quoted in the following figures as closely as can be done, but in some instances there is no basis for close quotations and in such cases a price is named which it is known could be done, but which in all probability could be shaded very materially should definite inquiry be made, such cases being indicated by the word nominal: Bessemer (nominal) $17; basic (nominal) $15; No. 2 foundry and malleable, $14.50; forge, $14, all at valley furnaces, 90 cents higher delivered Pittsburgh or Cleveland; No. 2 foundry, Philadelphia, $16.75; Buffalo, at furnace, $15.50; No. 2 foundry, delivered Cleveland (nominal) $15.25; Chicago, at furnace, (nominal) $16; Birmingham, $11.50.

Steel

A complete change has occurred in unfinished steel. For several months during the winter the mills refused absolutely to sell for forward delivery, while brokers, and an occasional small mill, offered odd lots for prompt shipment, prices being generally about $29 for billets and $30 for sheet bars. Buyers could not have afforded to pay similar prices for large tonnages for extended delivery, but as none such were offered even at those prices, the general market, such as it was, had to be quoted at $29 for billets and $30 for sheet bars. Early in April limited sales began for third quarter, $27.50 being accepted for third quarter sheet bars. The prompt market declined slightly, but there were two distinct markets, prompt and forward. In May the mills began not only to shade third quarter prices, but to undertake to anticipate some deliveries, until toward the close of the month the June steel offered at third quarter price could be considered prompt steel, and the disappearance of the prompt market, at a premium, was complete. We quote billets at $26.50 and sheet bars at $27, f.o.b. maker's mill, Pittsburgh or Youngstown, with buyers holding off and evidently expecting still lower quotations. An interesting feature is that the offerings are chiefly open-hearth and it might be impossible to obtain Bessemer as cheaply, whereas in the winter Bessemer was in better supply and if wanted at all could frequently be obtained at a concession from the open-hearth level.

Finished Steel

The remaining premiums for prompt deliveries of finished steel have practically disappeared, though small lots of plates sometimes bring $1 a ton advance, and steel bars frequently command $1 to $2 a ton, but only in quite small tonnages. Regular prices are not shaded to any material extent, there being slight irregularities in pipe and wire. The shading of $2 a ton in galvanized sheets noted in April has produced a regular market at 3.40 cents, and this price is now sometimes shaded. We quote regular prices as follows, f.o.b. Pittsburgh unless otherwise stated:

Rails, standard sections, 1.25 cents for Bessemer, 1.34 cents for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.45 cents.

Shapes, 1.45 cents.

Steel bars, 1.40 cents, base.

Common iron bars, 1.65 cents, Pittsburgh; 1.67½ cents, Philadelphia; 1.57½ cents, Chicago.

Wire nails, $1.80 per keg, base; plain wire, 1.60 cents.

Sheets, blue annealed, 10-gage, 1.75 cents; black, 28-gage, 2.35 cents; galvanized, 28-gauge, 3.40 cents; painted corrugated, 28-gage, 2.55 cents; galvanized corrugated, 28-gage, 3.50 cents.

Tin plates, $3.60 for 100-lb. cokes.

Merchant steel pipe, ¾ to 3-in., 79½ per cent off list.

Steel boiler tubes, 3½ to 4½ in., 70 per cent off list.

Standard railroad spikes, 1.80 cents.

Button-head structural rivets, 2.10 cents; cone-head boiler rivets, 2.20 cents.

The Non-Ferrous Metal Market

The situation in the non-ferrous metal market since our last report is not greatly improved. The price for lead was raised temporarily, but reduced again without apparent reason. Spelter has been unusually dull, with prices tending downward. An upward tendency has been noted in copper, and tin has held its own.

Copper.—The market for this metal improved steadily in the early part of May. Foreign demand was greatly increased by reason of the more settled political conditions in Europe, and domestic business also was better. The last quotations are: Lake 15¾, 16 cents; electrolytic 15.55, 15.60 cents.

Tin.—Domestic consumers have not shown great activity, and spot tin has been offered below the importation price. May tin is quoted at 49¼ cents, New York.

Lead.—Business in this market has been very quiet following the unexpected reduction in price by the American Smelting & Refining Company. Recent quotations have been unchanged at 4.20@4.25, St. Louis, and 4.30@4.35 cents New York.

Spelter.—This market has been without feature except the steady decline in prices and the unwillingness of consumers to purchase even at the prevailing low market. The last quota-

tions are 5.25@5.30 cents, St. Louis, and 5.40@5.45 cents, New York.

Other Metals.—The aluminium market is not active and there is little new business. Quotations are 26¼ cents, New York. Antimony has been dull, and quotations have not changed much. The last are 7.70@7.79 cents for various brands. The market for quicksilver is quiet, with prices unchanged. The New York price for flasks of 75 lb. is $39; San Francisco, $38.50 for domestic, and $36 for export orders.

The Western Metallurgical Field

Varied Activity in Nevada

Since the destruction by fire of its cyanide mill over a year ago, the Florence Goldfield Mining Company has confined its activities wholly to mine exploration work in the hope of developing new ore which would warrant the rebuilding of the mill. This work has been conducted on the upper levels of the mine, and no effort has been made to search for ore on the lower levels. The net result is that sufficient ore has been found to warrant a resumption of milling operations, although no new plant will be erected at this time. Arrangements have been made with the Jumbo Extension Company to use half of its 20-stamp mill, the Bonnie Clare. Half of the mill has been remodeled, and both companies will treat their ores separately. This arrangement will permit the Florence company to treat about 1500 tons of ore monthly, and in the meantime continue mine exploration.

A new consolidation is reported to be under way at Ely, Nev., involving a combination of the Giroux Consolidated, Coppermines Company, Butte and Ely, and Chainman Consolidated. The Giroux Consolidated is reported to be the nucleus of a company witht $8,000,000 capital, in which the various companies will enter on the basis of their present stock issues and values. The Giroux is controlled by the Thomas F. Cole interests, which in turn controls the Butte and Ely. The other two properties are owned by the Gunn-Thompson company. It is hoped by the promoters of this consolidation that it will prove the means by which the Giroux may be made the success it was originally expected to be. At present one section of the Nevada Consolidated mill at McGill is devoted to the concentration of Giroux ore.

The Nevada Cinnabar Company will erect a reduction furnace on its property this summer, for the treatment of ore from its quicksilver claims. Mine development has been under way for some time past, and a sufficient tonnage of ore has been found to warrant the erection of a plant to treat 50 tons of ore per day.

Idaho

The state law of Idaho requires mining companies to file with the assessor complete reports of their production, expenses and profits from annual operations. These reports for 1912 have now been made public, and it appears that the lead mining companies in the Coeur d'Alene district made a gross production valued roundly at $14,000,000. The total cost of extraction and treatment was $5,678,000, and the net profit $3,407,000. The Bunker Hill & Sullivan again holds the first rank among Coeur d'Alene companies, having net earnings slightly in excess of $1,000,000, which is $300,000 ahead of the next largest producer. The Stewart made the best showing compared with the record for 1911, its net earnings exceeding those of last year by 100 per cent, amounting to $395,000 out of a gross production of $1,471,500. The Federal M. & S. Company had a gross yield valued at $4,645,000, but netted only $653,876.

Minerals Separation Suit at Butte, Mont

The Minerals Separation Company, controlling patents for the concentration of ores by flotation, brought suit against the Butte & Superior Copper Company for infringement by the use of the so-called Hyde process in its mill at Butte. The case was heard in April, but no decision has as yet been handed down. The Butte & Superior company has been using flotation for some time, having installed a process patented in the United States by James H. Hyde, who, it is claimed, is using the Minerals Separation process.

The first annual report of the Butte & Superior company has been issued, showing that ore blocked out and ready for mining and treatment amounts to 1,200,000 tons, containing 21.7 per cent zinc and 7.9 ounces silver per ton.

Effects of Depression Felt in Utah

The general depression in the Western mining industry, first felt keenly by Colorado, is now being observed in Utah, and steps are being taken to revive an interest in legitimate mining in that state. The conditions there are practically a repetition of those existing in Colorado, namely, a lack of prospecting and consequent failure to discover and open new mining districts. Interest lags among those who have already made money in mining, and the commercial clubs of Salt Lake and other cities are considering ways and means for attracting local moneyed men back to mining as a business. Salt Lake City feels the local depression the more keenly because it maintains a local mining stock exchange, in which activity has been steadily decreasing. The small investor is not attracted to mining stocks, with the consequence that few new companies are formed of local men, and the largest operations are carried on by foreign corporations which remove the bulk of their profits from the state. The general consensus of opinion is the same as that reached in Colorado, and is to the effect that if the state is to profit to the greatest extent by mining, then more local money must be expended in the industry. Mining propositions must be presented on a sane business foundation, and the public encouraged to invest on a business basis.

The May meeting of the Utah Society of Engineers was held at Salt Lake City on the 16th ult. Mr. L. M. Bailey, general manager for the Portland Cement Company, of Utah, presented a paper on the manufacture and uses of cement. On the day following the meeting, the Society visited the plant of the Utah company.

Flotation at the Inspiration

In this journal for March, 1913, editorial comment was made on the fact that the Inspiration management had abandoned further work on its proposed new concentrator until experimental work could be completed on flotation by the Minerals Separation process. Since that time, and without waiting for the decision of the suit of the Minerals Separation mentioned above, the Inspiration company has practically decided to adopt the process. The first experimental unit was of 50 tons capacity only. This has been followed by a plant of 600 tons capacity, and on the results obtained in this mill the determination to build a larger plant will be based. If the results are as favorable as expected, a 7500-ton mill will be erected. The earliest experiments indicated a saving of from 93 per cent to 94 per cent of the copper in average Inspiration ore, the concentrate carrying up to 40 per cent copper. This is an excellent result, and one believed impossible with copper ores of this character. It may be said that Inspiration is fortunate in delaying its original plans, for in case flotation is adopted the original cost of plant will be far less than would have been expended for the standard type of concentrating mill.

Company Reports

Nipissing Mines Company.—The annual report for 1912 states that the high-grade mill ran continuously and successfully through the year, treating 1752 tons of Nipissing ore averaging 2212 oz. silver per ton, and 90 tons of custom ore. Bullion shipped amounted to 4,258,641 oz. A sampling plant was added and a blast furnace installed in the refinery for the reduction of slags, flue dust and precipitate. A new reverberatory furnace was built for refining the precipitate from the low-grade mill, so that practically the entire silver product of the mine is now shipped as bullion over 997 fine.

The low-grade mill was completed in 1912, but was not in full operation until 1913. During February, 1913, the mill handled over 200 tons ore per day. A feature of the practice is

precipitation of silver on aluminium dust. The precipitate, after drying, contains 93 per cent silver, and can be melted bullion 999 fine in one operation. The total cost of the mill and accessory plant was $324,650, and it is expected that this cost will be returned in six months. Sufficient ore is in sight to keep the mill running at present capacity for 2½ years.

Porphyry Copper Companies.—The annual reports of the Utah Copper Company, Ray Consolidated Copper Company, Nevada Consolidated Copper Company, and Chino Copper Company, have been issued, from which we take the following data, conveniently arranged for comparison:

	Ray	Utah	Nevada	Chino
Mill capacity, tons per day	8,000	21,000	8,000	6,000
Ore reserves, tons	82,904,368	337,700,800	38,853,551	90,000,000
Copper in reserves, %	2.19	1.5	1.67	1.8
Ore milled, tons	1,565,875	5,315,321	2,852,515	1,120,375
Copper in ore milled, %	1.68	1.36	1.692	2.077
Ratio of concentration	.....	.....	9.09	16.56
Copper in concentrate, %	18.95	20.75	10.49	21.20
Extraction, %	68.28	66.32	68.25	61.63
Cost of milling, cents per ton	46.88	41.58	.....	58.57
Copper produced, lb	35,861,496	96,175,090	63,063,261	28,684,208
Cost copper per lb., cents	9.83	9.02	8.86	7.69

Boston Meeting of the American Institute of Chemical Engineers.

The sixth semi-annual meeting of the American Institute of Chemical Engineers will be held in Boston, Mass., from June 25 to 28. All the professional sessions will be held at the Engineer's Club.

On Wednesday, June 25, a business session will be held at 9:30 a. m., which will be followed by the reading and discussion of the following papers:

Effect of climate on plant location, by Mr. William M. Booth.

The power plant, by Mr. Barker, of Arthur D. Little, Inc.

Relation of the manufacturer to the patent system, by Dr. William M. Grosvenor.

In the evening of Wednesday a session will be held at 8 o'clock devoted to the presidential address of Dr. T. B. Wagner and a paper on general efficiency in dye houses and bleach houses by Dr. Louis J. Mathos.

On Thursday, June 26, an evening session will be held devoted to the reading and discussion of the following papers:

Depreciation and obsolescence, by Mr. Richard K. Meade.

Some peculiar functions of the retained expert, by Dr. William M. Grosvenor.

Legal control of dangers to health in factories, by Dr. Charles F. McKenna.

On Friday, June 27, an evening session will be held at 8 o'clock, devoted to the reading and discussion of the following papers:

Import duties on chemicals and their influence on the chemical industry, by Dr. F. W. Frerichs.

The drying of linseed oil and red lead with special reference to painting steel, by Dr. J. C. Olsen and Mr. A. H. Callaghan.

This will be followed by the final business session.

The program of visits and excursions is very full. In the afternoon of Wednesday an excursion will be made to the works of the Hood Rubber Company, at Watertown (manufacturers of rubber shoes, automobile tires, etc.). Alternate visits have been arranged for the same afternoon to the U. S. Arsenal at Watertown and to the laboratories and experimental paper mill of Arthur D. Little, Inc.

On Thursday morning a train will take the members to Lawrence, Mass., where two parties will be formed to visit the Pacific Mills (cotton goods and prints) or the E. Frank Lewis' Wool Scouring Establishment. In the afternoon a visit will be paid to the works of the Russell Paper Company (wood pulp by soda and sulphite processes, and manufacture of book and print paper).

For Friday an all-day excursion on a special ocean-going tugboat has been arranged as follows: The party will be first taken to the New England Gas & Coal Company, Everett, Mass. After the inspection of this plant the party will be taken to Marblehead, Mass., where dinner will be taken at the Eastern Yacht Club. On the return trip of the boat to Boston a stop will be made at the new power plant of the Boston Elevated Railroad if time permits.

On Saturday an excursion will be made to Providence, R. I., where two parties will be formed to visit either the works of the Gorham Manufacturing Company (silversmiths and goldsmiths, plated ware, bronzes, etc.) or the plant of the United States Finishing Company (large cotton finishing plant, bleaching dyeing, printing).

Dr. J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y., is the secretary of the American Institute of Chemical Engineers.

International Engineering Congress at San Francisco, 1915

In connection with the Panama-Pacific International Exposition which will be held in San Francisco in 1915, there will be an International Engineering Congress, in which engineers throughout the world will be invited to participate.

The Congress is to be conducted under the auspices of the following five societies: American Society of Civil Engineers, American Institute of Mining Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, and The Society of Naval Architects and Marine Engineers.

These societies, acting in cooperation, have appointed a permanent Committee of Management, consisting of the Presidents and Secretaries of each of these Societies, and eighteen members resident in San Francisco.

Thus constituted, the personnel of the committee is as follows: For the American Society of Civil Engineers: Geo. F. Swain, president; Chas. Warren Hunt, secretary; Arthur L. Adams, W. A. Cattell, Chas. Derleth, Jr., Chas. D. Marx.

For the American Institute of Mining Engineers: Charles F. Rand, president; Bradley Stoughton, secretary; H. F. Bain, Edw. H. Benjamin, Newton Cleaveland, Wm. S. Noyes.

For the American Society of Mechanical Engineers: W. F. M. Goss, president; Calvin W. Rice, secretary; W. F. Durand, R. S. Moore, T. W. Ransom, C. R. Weymouth.

For the American Institute of Electrical Engineers: Ralph Davenport Mershon, president; F. L. Hutchinson, secretary; J. G. De Remer, A. M. Hunt.

For The Society of Naval Architects and Marine Engineers: Robert M. Thompson, president; D. H. Cox, secretary; Geo. W. Dickie, W. G. Dodd, Wm. R. Eckart, H. P. Frear.

The committee has effected a permanent organization, with Prof. Wm. F. Durand as chairman, and W. A. Cattell as secretary-treasurer, and has established executive offices in the Foxcroft Building, 68 Post Street, San Francisco.

The ten members of the committee, consisting of the presidents and secretaries of the five national societies will constitute a Committee on Participation, through whom all invitations to participate in the Congress will be issued to governments, engineering societies, and individuals. Mr. Chas. F. Rand is the chairman and Mr. Chas. Warren Hunt the secretary of this committee.

The papers presented at the Congress will naturally be divided into groups or sections. During the Congress each section will hold independent sessions.

"The scope of the Congress has not as yet been definitely determined, but it is hoped to make it widely representative of the best engineering practice throughout the world."

Importations of graphite largely exceed domestic production, according to the 1912 figures of the Geological Survey. The imports in 1912 amounted to 25,643 tons, valued at $1,709,337; domestic production of natural graphite, 2455 tons, valued at $207,033; production of artificial graphite, 6448 tons, valued at $830,193.

Award of the Willard Gibbs Medal to Dr. L. H. Baekeland

Reception and Banquet

The presentation of the third Willard Gibbs medal to Dr. Leo. H. Baekeland of Yonkers, N. Y., formed the occasion for a congratulatory banquet at the Hotel Sherman in Chicago on May 16. The arrangements for the entertainment and banquet were under the auspices of the Chicago section of the American Chemical Society. Mr. William A. Converse, founder of the Willard Gibbs medal, was present at the banquet. The medal is awarded each year to a man who has gained pre-eminence in chemical research.

Preceding the dinner was a reception, which afforded the younger chemical fraternity an opportunity to meet some of the most distinguished educators and industrial chemists of this country. About 150 ladies and gentlemen were present.

After the reception the guests repaired to the Louis XVI room to inspect the exhibit of the bakelite products which were displayed on tables. The room was specially decorated with American flags. Charts bearing graphic representations of chemical compounds, which require the use of polysyllabic names to designate them in chemical nomenclature, lent a distinct color to the meeting which was much in keeping with the profession represented at the banquet.

L. H. BAEKELAND

There was a most interesting display of the many articles which have been made from bakelite, illustrating the wonderfully manifold applications which these new infusible and insoluble phenolic condensation products have found. These applications vary from cigar holders to switchboards for battleships; from grind-stones to self-lubricating bearings; from the most effeminate jewelry to acid pump valves; from brass bedstead lacquer to phonograph records; from billiard balls to automobile magnetos; from unbreakable dolls to electrical machinery; from buttons to newspaper stereotyping matrices.

Following the banquet, Professor **Julius Stieglitz,** chairman of the Chicago Section of the American Chemical Society, addressed the guests. In his address, which was on "The Willard Gibbs Medal," he said that the two medals which were awarded previously were presented to pure chemists; that is, to men occupied entirely in theoretical science—Svante Arrhenius and Theodore W. Richards. This is the first time that the medal has been awarded to a man pre-eminent in applied chemistry.

Presentation Speech of Dr. W. D. Richardson

Dr. W. D. Richardson in presenting the Willard Gibbs medal to Dr. Baekeland spoke in part as follows:

"We have gathered here to-night in recognition of the services of one who has materially aided human progress, and in adding to the sum of knowledge has increased the sum of human happiness. To emphasize or memorialize this recognition we are to present our guest of honor with a medal, founded by Mr. Converse, and named in honor of Willard Gibbs, who, although known as a mathematical physicist, was in fact one of the most illustrious chemists of this country.

"The man who accepts a medal takes upon himself a heavy responsibility. Like the man in the story, he places himself in the hands of his friends in a most absolute way. There is no relief or rest for him from the time he arrives in town until he is safely aboard a train and on his way home. There is every likelihood of his being over-entertained and overfeasted. But worst of all people inquire what he has done to merit the award and look up his record as though he were a politician of another party. And by accepting the medal and placing himself at the mercy of his friends he may even have to sit patiently and listen to a recital of some or all of his scientific labors and results and appear to be at ease. Dr. Baekeland, I hope you will be able to bear the worst that is to come with fortitude and a smile. Where the record is clear, where the work has been well and permanently done, there should be no embarrassment to the doer in the admiration of his friends. In such work a man may most properly show his pride without fear of the charge of egotism.

"The needs of the world increase with the age of the world. It was not long ago that people got along very well without railroads and steamships, automobiles, and air ships; not long ago that they got along without the tungsten, arc, carbon-filament and mercury-vapor lamps; without gaslight and kerosene light—indeed, it was only 100 years ago that there was no stearic acid candle! and the animal and vegetable fats and oils were used for illumination. The chemical inventor of to-day fills a new want as often as he does an old one. Or he may even create a want where there was none before."

Dr. Richardson then outlined the wonderfully successful work of Dr. Baekeland in three different fields of chemistry. First, in the field of photo-chemistry he invented the developing-out paper or gaslight paper and thus revolutionized photographic print making. "Velox" was the very felicitious name applied to the invention—the same velox made by the Eastman Company to-day and known to all photographers.

Second, in electrochemistry Dr. Baekeland perfected the Townsend cell for the manufacture of electrolytic alkali and chlorine which is now in commercial operation at the works of the Hooker Electrochemical Company at Niagara Falls, N. Y., where 34 tons of caustic soda are manufactured daily and within a year the capacity is to be increased to 64 tons per day. Recently the Farbenfabriken of Elberfeld has adopted the Townsend cell in its works.

Dr. Baekeland's last, and as he looks upon it, his most important work has been in the field of organic chemistry, and consists in the invention and manufacture of condensation products of phenol and formaldehyde. At present the product bakelite is worked up in twenty-four different industries. In the button industry alone about one thousand workmen are employed on the product.

Dr. Richardson then continued:

"But if I were asked to sum up in a few words the genius of Dr. Baekeland I should say that it is comprised in his ability to follow an idea to its conclusion. In the case of each of his discoveries he has not been satisfied with the mere discovery,

however important it was; but in every instance he has carried his work to a practical conclusion—from the laboratory to the factory and from the factory to the public. Let us see what this entails.

"In the first place a man must have faith in his idea; not only that but faith in himself. Then he must have the scientific knowledge and technical skill necessary to carry his discovery through the laboratory stages and to the small manufacturing stage. Following this the larger factory must be built and started in operation. In the meantime, if the inventor's future rights are to be protected, the inventions must be carried through the patent office—a matter of no small importance, and requiring no small amount of information. Then the company must be organized and capitalized and directed. Finally, if the inventor is to be completely successful, he must be a good publicist in order to bring his discoveries before the great consuming public. In all these departments of activity Dr. Baekeland stands pre-eminent.

"And now, having exposed thus briefly the splendid record of our guest, in this barefaced fashion, before him and you—an ordeal which he has borne with the utmost fortitude—I have only the duty left of presenting the Willard Gibbs medal.

"Dr. Baekeland: This medal can add nothing to your achievements. Your work and your inventions have already received their merited recognition by your scientific colleagues and by the world of practical affairs. But in presenting you with this medal the Chicago Section of the American Chemical Society not only desires to give recognition to your discoveries in a very special way, but more than that, to link your name with those of the famous men who have preceded you—Arrhenius, Richards, and the one after whom the medal is named, Willard Gibbs, as well as with many more who will follow you in after years.

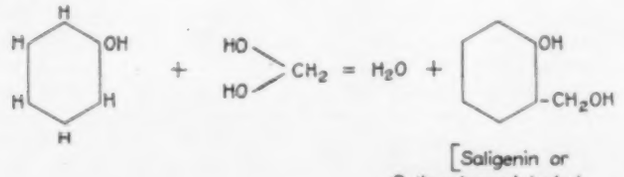
"In the name of the Chicago Section and the founder, Mr. Converse, I now present to you the third Willard Gibbs medal."

Dr. L. H. Baekeland's Address on the Chemical Constitution of Resinous Phenolic Condensation Products

Dr. Leo. H. Baekeland replied with a few gracious felicitous words of thanks, and with the modesty which is so characteristic of the man said that "friendship and good feeling often bring about an alteration of good judgment."

Dr. Baekeland then presented a long and very interesting address on "The Chemical Constitution of Resinous Phenolic Condensation Products," dealing with the purely theoretical side of the subject. Only an abstract of this address can be given here. He pointed out that the study of the chemical reactions involved in these processes is, by no means, an easy one. Bodies of a resinous or colloidal nature, which neither crystallize, nor melt, nor distill, nor dissolve, do not belong to the class of substances easy to purify nor to be studied with some hope of accuracy.

By conducting the action of formaldehyde on phenol under suitable conditions, a very clean-cut reaction takes place, giving the simplest phenolic condensation product, oxybenzylalcohol or saligenin. In this case, formaldehyde reacts as methylenglycol.

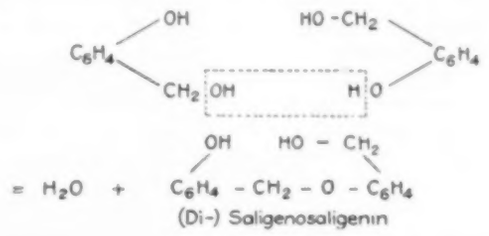


[Saligenin or Orthoxybenzylalcohol

In this same reaction, more or less large amounts of paraoxybenzylalcohol are formed at the same time. But saligenin or oxybenzylalcohol is very easily disturbed by dehydration, and then changes into a resinous mass. This dehydration can occur by simple application of heat, and is much hastened by the presence of strong acids or other chemical agents. This is the reason why in the processes of the preparation of oxybenzylalcohol, low temperature and general careful treatment are essential.

Unless such careful precautions be observed, the reaction gets beyond control and resinous bodies are sure to be produced in predominant quantity. This is especially the case when strong acids are used as condensing agents; but even under such conditions Dr. Baekeland has succeeded, in his laboratory, in establishing the presence of noticeable quantities of oxybenzylalcohol. In the process of preparation of phenol-alcohols, the conditions of procedure and necessary precautions are, therefore, widely different from those required in the production of synthetic resins.

The resinous dehydration products, derived from phenol-alcohols, are known and have been described long ago as saliretin products. Some have proposed a chemical structural formula for these products. For instance, it has been assumed that the first dehydration product, disaligenosaligenin, is formed as follows:



(Di-) Saligenosaligenin

In the same way a trisaligenosaligenin and a heptasaligenosaligenin are formed.

However attractive all such formulas may appear to enthusiastic novices in organic chemistry, the sobering fact remains that every one of above mentioned substances is of a highly resinous nature. Whether their constitution is as simple as indicated by above formula, is a mere matter of conjecture. All that can be stated with any degree of certainty is that oxybenzylalcohol, by a process of dehydration, loses water and turns into ill-defined resinous bodies designated under the generic name of saliretins.

To try to establish nearer the structural constitution of their molecules, is out of the question. That the gradual elimination of water should decrease the fusibility of these bodies and accentuate their insolubility, seems almost self-evident to any chemist and requires no further explanation.

Dr. Baekeland discussed at considerable length the work done by many investigators on fusible soluble condensation products. All these *fusible, soluble* phenolformaldehyde resins described by Blumer, Delaire, Lebach, Knoll-Wetter, Bayer & Co., Aylsworth and others, have practically the same chemical and physical properties, differing only in minor details by the way in which they are prepared and by the more or less large amount of free phenol they may contain. Dr. Baekeland had proposed heretofore to designate all these relatively simple fusible soluble phenolic condensation products under the generic name of Novolac or they may just as well be called fusible saliretin products.

From different sources many attempts have been made as far back as 1902, to utilize these soluble artificial resins, as shellac substitutes, or as substitutes for other natural resins in the manufacture of varnish. In this respect they were of special interest, a few years ago, when the market price of shellac was unusually high. But it seems that none of these products has fulfilled the expectations of industrial use.

Nowadays, the main importance of these shellac substitutes resides in the fact that they bear an immediate relationship to another class of bodies, the so-called *infusible insoluble* phenolic condensation products, which have been designated by such names as bakelite, resinit, condensite, and which Dr. Lebite called resites.

The second part of Dr. Baekeland's address dealt with the chemical constitution of these infusible condensation products

of maximum hardness and resistivity. He pointed out that the very fact that these bodies are infusible and insoluble, and that they are characterized by a much more pronounced chemical and physical inertness than the so-called Novolak resins or saliretin products, makes it still more difficult to study their chemical constitution.

All that can be said now with some probability is this:

First, that these bodies are phenolic condensation products of formaldehyde, or of equivalent methylen-group-containing substances, this condensation process having for result a corresponding enlargement of the so-called carbon nucleus of the molecule.

Furthermore, it is a well-accepted fact that in these reactions, formaldehyde can be replaced by its many equivalents; methylal, methylenacetate, hexamethylentetramine, the polymers of formaledhyde, paraform, etc., have all been tried with success. Even products like monochlormethylether may lend their methylene-group in reacting with phenol and form hard, insoluble condensation products.

Secondly, that after the so-called condensation has taken place, polymerization sets in, with the result that the molecules of the condensation product form by aggregation or regrouping so-called polymerized molecules of much higher molecular weight; and the chemical and physical dynamics of these enlarged polymerized molecules are proportionately lessened. This at once explains the higher specific gravity and contraction of the polymerized product as well as the greater inertness or resistivity.

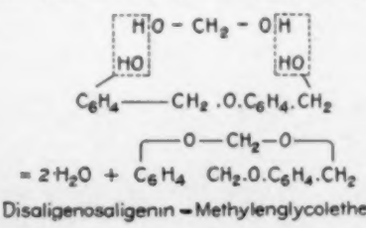
This also explains why many other aldehydes or phenolic substances may react with another and give condensation products, and yet not undergo further polymerization, and on this account, do not possess the properties of hardness, strength and resistivity, which here lend special technical value.

If we go beyond these mere general theoretical conceptions and try to interpret the intimate chemical constitution of these bodies in about the same way as we are able to do with the relatively much simpler crystalline or volatile organic compounds, then our flights of fancy are justified to take as well one direction as another, because our flying machine brings us in zones where readable charts, etc., are unavailable.

Dr. Baekeland reviewed the different hypotheses which have been proposed in succession, the first one by himself in 1909, when he proposed the constitution as oxybenzylmethylenglocolanhydride or hexasaligenosaligeninmethylenglycolether. This simple way of interpretation has the advantage that it accounts for the possible existence of any number of similar bodies made with a varying proportion of formaldehyde. For instance, it leaves the possibility of imagining that a product may exist which is derived from more than six molecules of oxybenzylalcohol and one molecule of methylenglycol, which then would show less chemical resistivity. In the same way, it allows to conceive varieties of the same product with a smaller number of molecules of phenol-alcohol entering into reaction with one molecule of formaldehyde or methylenglycol.

Numerous facts point to the existence of such modified bodies of which the chemical and physical inertness increases with the lesser amount of molecules of phenol-alcohol, which enter into reaction with one molecule of methylenglycol; or to put it simpler, of which the resistivity increases with the larger amount of formaldehyde, which reacts with a given amount of phenol.

Dr. H. Lebach called attention to the existence of a condensation product resulting from the action of one molecule of methylenglycol (formaldehyde) on disaligenosaligenin.

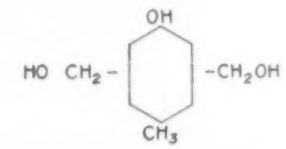


Disaligenosaligenin – Methylenglycolether

The latter corresponds, in practice, to condensation products resulting from the direct reaction of two molecules of phenol on three molecules of formaldehyde.

Dr. Baekeland then discussed at some length the hypothesis of Dr. F. Raschig, who has taken up the subject from quite a different point of view and has tried to show the possible relationship of these infusible condensation products with diphenylemethan derivates.

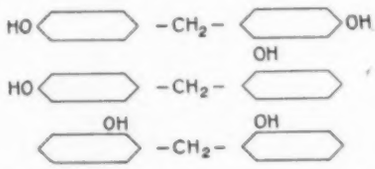
Dr. Raschig supports the opinion that the first and simplest stages in the reaction are the formation of ortho- and paraoxybenzylalcohol. He points out, however, that in case paracresol is used a well-known dialcohol phenol may be formed by further action of one molecule of formaldehyde



which again on heating sets free formaldehyde. In the case of phenol, the first resulting phenol-alcohol may react on a further molecule of phenol and give dioxydiphenylmethan.

Or one molecule of phenol-alcohol may react either with another molecule of the same phenol-alcohol, or of another phenol-alcohol, and produce, for instance, a dioxydiphenylmethan with a carbinol group, and all these reactions may occur simultaneously. Such a new phenol-alcohol may react on another molecule of phenol, and this condensation process may continue still further.

Dr. Raschig calls attention that the phenol-alcohols when reacting on phenol may produce at least three different isomeric bodies:



and that by further proceeding steps in the reaction the number of possible isomeric bodies and different compounds engendered by them becomes so limitlessly large that we know of no scientific methods which would enable us to identify them all. Commenting on this fact, he states that the amorphous character, as well as the valuable technical qualities of the end products, are probably due to the great variety of the different bodies which are all contained therein, including, at the same time, extraneous bodies like free phenol, etc.

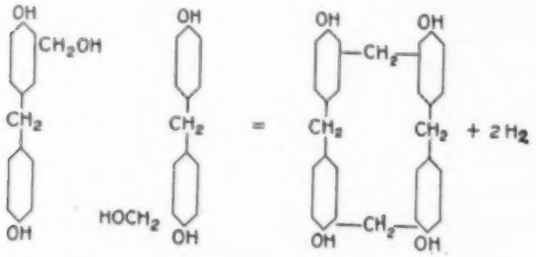
Further, Dr. Raschig seems to infer that the production of the soluble variety condensation products is merely determined by the relative amounts of phenol and formaldehyde, and he argues that in case insufficient formaldehyde be used, a mixture of the three isomeric dioxidiphenylmethans should be the result, while if more formaldehyde is present, then the corresponding phenol-alcohols of those dioxydiphenylenmethans will be formed; the latter can react further upon another and in this way build up a much larger molecule which accounts for the insolubility and great resistivity of these large molecules, of which the dynamics are correspondingly decreased.

Dr. Baekeland expressed the opinion that this theoretical interpretation only holds good to a certain extent. While it is possible, and even probable, that some of the bodies mentioned by Dr. Raschig, exist in the first phases of the reaction, or may exist in the final products together with an endless variety of other chemical individuals, we know next to nothing of the relative importance thereof, whether they exist as traces or whether they play a fundamental role.

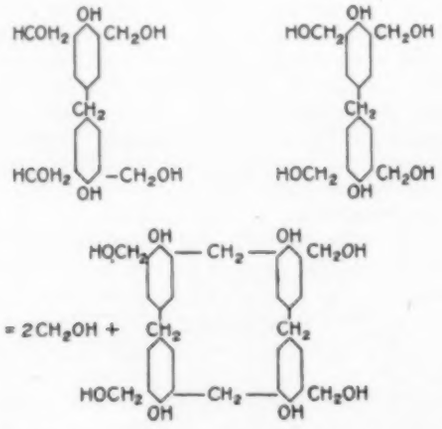
Further, Dr. Raschig seems to overlook the very important and well-established fact that the nature of the condensing agent has an enormous influence on whether fusible or infusible products will be formed. For instance, it is known that if we operate in presence of small amounts of bases, in-

fusible condensation products will be the result whether we use an excess of phenol or not.

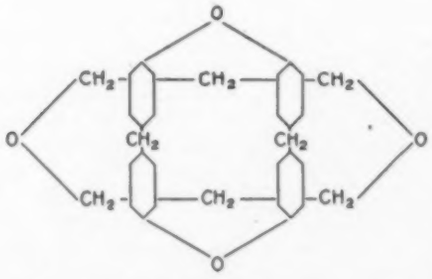
Dr. Raschig has outlined some further theoretical interpretations from the standpoint of the assumption that diphenylmethan derivates are the main products in this process. He has shown for instance, how under certain conditions, a body may be conceived which he calls bakelite I:



and then again another body resulting from a larger proportion of formaldehyde,



which after dehydration gives a molecule which Raschig calls bakelite II.



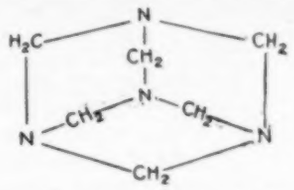
Dr. Baekeland concludes that much as these speculative considerations presented by a scientist of reputation, may be able to give food for thought, we must not forget that one hypothesis is about as easy to propose as another as long as we are unable to use any of the methods for determining molecular size and molecular constitution.

Lately Wohl has advanced a radically new hypothesis which considers these bodies as polymerization products as methylenederivates of the tautomeric phenol.

In whatever theoretical speculations we engage on this subject, we must not lose sight of the fact that the nature of the condensing agent may have an enormous influence on the way the reaction takes place, even if at the end the products may look very much alike and be more or less identical.

For instance, when an acid condensing agent is used the process seems to proceed very differently from what happens when alkalies are used. Then again, when ammonia is used, the reactions which succeed each other seem to be quite different. In the latter case they can be followed to quite an extent (Lebach).

For instance, every chemist knows that ammonia, on acting on formaldehyde produces immediately hexamethylentetramine



In the same way, if ammonia be added to a mixture of phenol and formaldehyde, the same hexamethylentetramine is formed independently whether the phenol or the ammonia is added first or last. In presence of the phenol, one molecule of hexamethylentetramine adds to three molecules of phenol and gives:

$$C_6H_{12}N_4, 3C_6H_5OH$$

hexamethylentetramintriphenol.

Under the action of heat this latter substance decomposes and sets free large amounts of ammonia gas, leaving finally a hard infusible body. But the ammonia can act immediately on new amounts of formaldehyde and repeat the same reaction so that a small amount of ammonia is sufficient to act as catalytic agent for all the formaldehyde present, and to carry on the whole reaction to the finish, after which free ammonia is found in the product.

The general reaction seems to be the same whether ammonia and formaldehyde be used in conjunction with phenol, or whether phenol be made to react directly on hexamethylentetramine or whether hexamethylentetraminetriphenol be destroyed by heat. In the latter case, however, the so-obtained product is very porous and does not present a sufficiently homogeneous colloidal mass as required for technical purposes. On this account the use of a somewhat larger amount of phenol or other suitable similar body becomes imperative so as to obviate this defect. Hence some excess of phenol or suitable solid solvent will accomplish technical results which are not otherwise possible when hexamethylentetramine is used alone.

Dr. Baekeland showed a cylindrical tube made of bakelite which was ruptured longitudinally. The fracture was so regular that it shows that bakelite is not a heterogeneous substance.

Dean **James R. Angell** of the University of Chicago, entertained the guests by the remarks which he made concerning the points which he said he had absorbed as an experimental psychologist from Dr. Baekeland's technical paper. In a more serious frame of mind he said that the attitude of the chemical departments of American universities toward industrial chemistry are too harshly criticized. He added that it is only by applying the mind to the highly theoretical phase of the science that the student can set himself on an unbiased plane furthering the development of chemistry.

Prof. **George B. Frankfurter** of the University of Minnesota, gave a short talk and expressed his pleasure at being able to attend a ceremony in honor of Dr. Baekeland.

The jury of award which selected Dr. Baekeland as the third Willard Gibbs Medalist comprised Prof. Alexander Smith, Dr. W. R. Whitney, Dr. E. C. Franklin, Prof. W. A. Noyes, Dr. J. D. Pennock, Prof. G. B. Frankfurter, Prof. John H. Long, Prof. Julius Stieglitz, Dr. William Brady, Mr. E. B. Bragg, Mr. S. T. Mather and Dr. G. Thurnauer.

Electroplating with Trisalzt is the title of an interesting little pamphlet explaining the advantages of trisalzt (a metallic triple salt) for electroplating and giving directions for preparing electrolytic baths with trisalzt. Recipes are given of copper baths, brass baths, bronze baths, zinc baths, gold baths and silver baths.

Graphite for the Boiler is the title of a booklet just published by the Joseph Dixon Crucible Co. This booklet deals with no new discovery, for graphite has been sold to remove scale from boilers for many years. It simply states in as few words as possible why Dixon's boiler graphite does its work.

Evolution of Methods of Handling Slime.—III

AUSTRALIAN PRACTICE.

By H. N. Spicer.

In the limited space of a short review, such as this series of articles is designed to present, it will be impossible to give more than a very general description of the varied methods of handling slime in such a large country as Australia. Diverse metallurgical processes are employed, and the slime problem varies in the different districts. In Broken Hill, New South Wales, for example, it is concerned with the concentration of lead-zinc ores, while in Kalgoorlie, Western Australia, it relates to the cyanidation of gold ores. In one respect, however,

FIG. 1.—BROKEN HILL PROPRIETARY CONCENTRATING MILL

the problem in all the districts has a common factor, viz., the conservation of water. Over practically the whole of Australia the water question is a serious one, and especially so in the mining districts, nearly all of which are situated at the edge of the great central desert. All sorts of schemes and devices, therefore, are adopted to recover water, this being quite as important as the saving of slime, or its proper preparation for treatment.

General Conditions at Broken Hill.

Broken Hill is the largest mining camp in Australia, and generally recognized as the home of flotation processes; but despite the acknowledged leadership of Broken Hill engineers in this branch of metallurgy, it is only recently that they have adopted methods of handling slime that are recognized as modern and efficient.

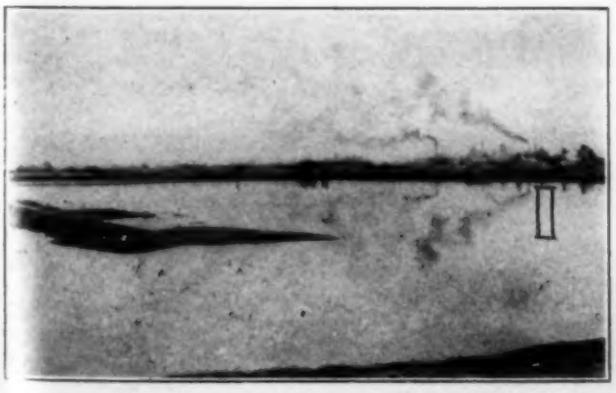


FIG. 2.—TYPICAL SLIME DAM AND SETTLING BASIN AT THE BROKEN HILL PROPRIETARY

The Broken Hill mines extend for a little more than three miles along the same line of lode, forming an isolated and compact mining camp. To the casual observer it might appear that all the mills are using the same metallurgical methods, but in reality no two mills are identical in process or operation, owing to the widely varying physical and chemical properties of the ores. Some mechanical features of the practice, however, are common to all mills. Gyratory rock breakers and rolls are generally used for crushing. Trommels are used for coarse screening, and revolving screens of the King type for finer work. For fine grinding the Australian pan, and ball and Huntington mills are usually adopted. The tube mill has been tried in more than one plant, but does not seem to have found favor. Jigs of the Hancock and May types predominate, as does the Weir-Merideth concentrating table which was produced by two of the leading engineers of the camp. The prevailing type of slime concentrator resembles a Frue vanner, and is also of local production. Hydraulic classifiers of one sort or another are in general use.

Necessity of Sand-Slime Separation.

One of the recognized requirements for successful flotation is a pulp containing little slime; and as flotation processes are widely used in Australia, it is imperative that a good separation of sand and slime be made, and equally necessary that the water be recovered from the latter. Formerly classification was done entirely by the use of spitzkasten, the slimy overflow being settled in pointed boxes, tanks or pits. Not only is it almost impossible to obtain a clear overflow by this method, but the recovery of water is incomplete, for the settled slime must

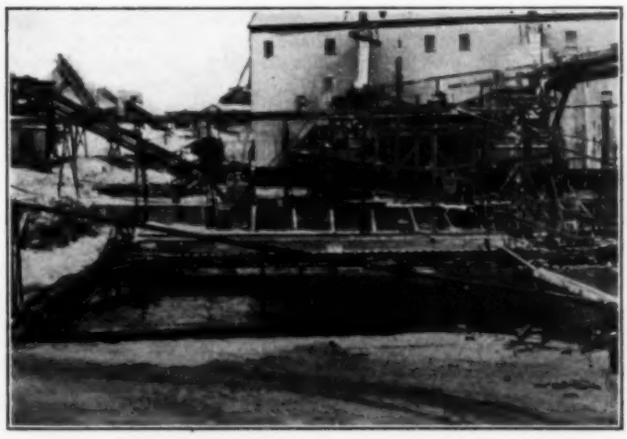


FIG. 3.—SLIME SETTLING PITS AT BRITISH BROKEN HILL

retain sufficient water to permit pumping or flowing by gravitation to the slime dams, where a further recovery of water is made.

Slime Settlement and Water Recovery.

A general view of the Broken Hill Proprietary mill is shown in Fig. 1. The first experimental plant for the treatment of slime by the Potter-Delprat acid flotation process occupies the white building in the center. At the extreme left is the lead concentrator from which slime and water are pumped to settling tanks placed on a high platform at the right near the stack. These tanks are emptied periodically, the pulp being sluiced to slime dams, one of which is seen in the left foreground. The walls of these dams, or basins, are gradually built up of slime and stand nearly vertical, as will be seen in some of the views. The Broken Hill Proprietary has many acres of such settling basins, a portion of which is shown in Fig. 2. As the area exposed is great, and the rate of evaporation high, the loss from this cause is appreciable.

At the British Broken Hill, where the Elmore vacuum flotation process is installed, large concrete pits are used as settlers. Two of these are shown in Fig. 3. As the slime flows into the pits, the supernatant liquor overflows and is returned to the mill. When a pit no longer gives a clear overflow, the slime is sluiced to a sump whence it is pumped to slime dams similar to that shown in Fig. 2. Further settlement is obtained at the dams, and clear water is pumped back to the mill.

In Fig. 4 is shown a view of the concentration and minerals separation flotation plant of the Zinc Corporation, with sand and slime dumps at the right. In the foreground can be seen ridges of slime that have been thrown up to form new settling basins for the recovery of water. An interesting feature of this

mill is the use of troughed conveyor belts for dewatering the sand tailing (contains also some slime) from the Minerals Separation boxes. The discharge end of three of these belts is shown in Fig. 5. The one at the left is used for concentrates, and the two at the right for tailings, the latter being discharged with from 16 per cent to 20 per cent moisture. The belts travel slowly, and gradually elevate the material to the discharge point, while the slime and water flow in the opposite direction to circular settling tanks, 60 ft. diameter and 8 ft. deep. One of these is shown in Fig. 6. Here some water is recovered, while the thick slime is sluiced to sumps from which it is pumped to the settling dams shown in the foreground of Fig. 4.

FIG. 4.—ZINC CORPORATION BROKEN HILL MINERALS SEPARATION PLANT, SAND AND SLIME DUMPS

As stated before, these slime dams are typical of Broken Hill. Those shown in Fig. 7 are especially interesting as showing how nearly vertical the walls can be built. The sand dumps at the right contain 1,250,000 tons of zinc tailings from the old Broken Hill South mill, and have been bought by the Zinc Corporation for treatment by the Minerals Separation process.

The huge sand dump shown in Fig. 8 is that of the Sulphide Corporation, where the Minerals Separation process is used for the recovery of zinc from the tailings of the lead concentration mill. The slime settling basins at the foot of the dump show only a part of the extensive arrangement provided for this purpose, there being also a number of large, circular collecting tanks. The settled solids are dug by hand from the pits and tanks, and returned to the Minerals Separation plant for recovery of the zinc content.

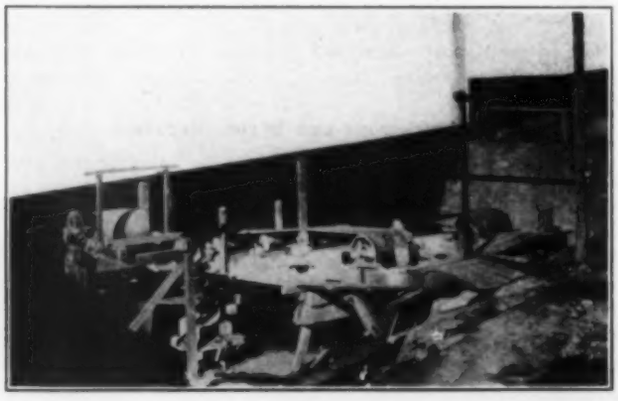


FIG. 5.—DISCHARGE END OF SAND-DEWATERING BELTS, ZINC CORPORATION, LTD.

Modern Methods First Adopted at Broken Hill Proprietary Block 10.

The last mill to be built in this camp was that of the Broken Hill Proprietary Block 10, a general view of which is shown in Fig. 9. It was the first to employ modern methods of dewatering slime, and commenced operations about one year ago.

That part of the plant formerly devoted to the separation of sand and slime, and the dewatering of the latter, prior to treatment by flotation, is at the extreme left in Fig. 9, but is shown more in detail at the right in Fig. 10. It consisted of six elevators, three filter-bottom, circular sand tanks and four V-shaped slime collectors. The pulp was elevated and discharged into the circular tanks where the sand settled, the slime overflowing to the V-shaped thickeners. These thickening boxes were built of lumber imported from the Pacific Coast of the United States and were erected at a cost of about $2,800. They were designed to handle the entire slime product of the concentrator. The overflow, which was expected to be reasonably free from slime, passed to the circular steel tank shown in the center, whence it was pumped to the storage tank shown on an elevation in the background. The method was not satisfactory, however, as the overflow from the V-shaped boxes carried considerable slime, with the consequence that the water storage tanks soon became half filled with solids.

The scheme was finally abandoned, and Dorr continuous thickeners were substituted for the V-shaped boxes. The first of these thickeners to be erected in Broken Hill is shown at the left in Fig. 10, with a closer view in Fig. 11. Five such continuous thickeners have been built at this mill, and today they handle the entire slime product, giving a perfectly clear overflow with practically no loss of head, and a thickened underflow carrying less than 50 per cent moisture.

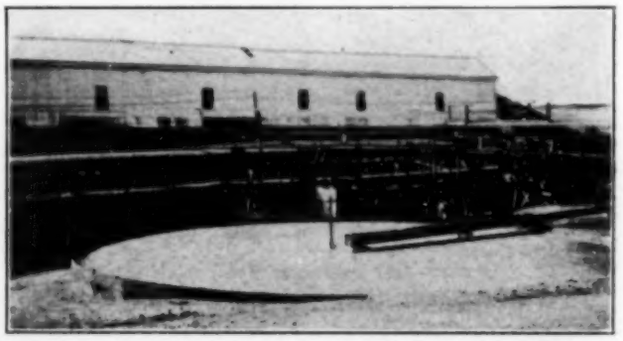


FIG. 6.—SLIME SETTLING TANKS, 60 FT. DIAMETER AND 8 FT. DEEP, ZINC CORPORATION, LTD.

In Fig. 12 is shown the mill of the Amalgamated Zinc Company, using the De Bavay flotation process. This company owns no mines, but has bought a large tonnage of old zinc tailings and has contracts to treat current zinc tailings from several companies which have only lead concentrating mills.

FIG. 7.—TYPICAL SLIME DUMPS, BROKEN HILL

A very elaborate system of flat-bottom, circular tanks has been installed in which to settle the slime, which is then pumped to slime dams. Close separation of sand and slime is necessary as the De Bavay process does not handle the latter material.

In concluding the review of slime handling in Broken Hill it may be stated that all forms of dewatering devices have been tried, including the Wilfley revolving filter, the Hunt horizontal filter and others, but until the introduction of the con-

tinuous slime thickener the problem was not successfully solved. These thickeners are now being widely adopted, with a consequent saving of water and cost of pumping.

The Kalgoorlie Goldfield, Western Australia.

In gold metallurgy the slime problem takes on a different aspect from that which it presents in the treatment of base metal ores. The ore slime is much more valuable, particularly when, as at Kalgoorlie, the fine portion of the crushed ore is almost invariably richer than the coarse. Slime thus becomes the bugbear of the metallurgist unless his plant is properly equipped to handle it.

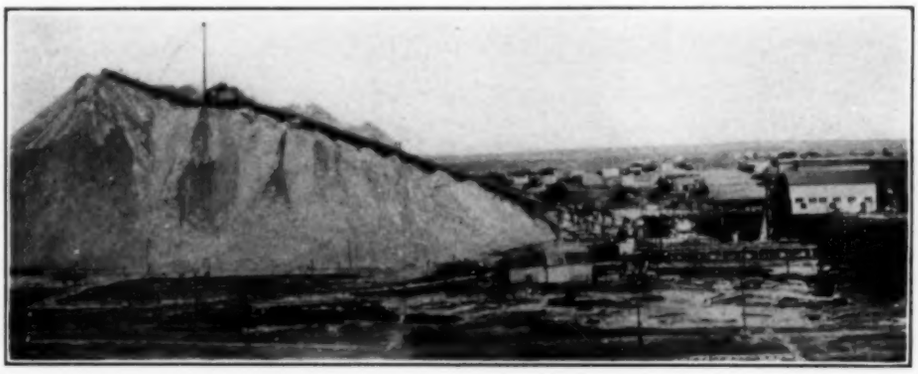


FIG. 8.—SAND DUMP, WITH SLIME SETTLING DAMS AT BASE SULPHIDE CORPORATION, BROKEN HILL.

Until recently it was the practice in Kalgoorlie to provide large settling areas in pointed boxes, for dewatering slime prior to filtration either in plate-and-frame presses or in the various forms of leaf filters. During the past year, however, the continuous thickener first adopted in Broken Hill has found considerable favor with Kalgoorlie metallurgists, and is rapidly being substituted for older and less efficient forms of thickening devices. At some of the mills, however, the older methods are still in use, as will be seen in Fig. 13, which shows part of the plant of the Great Boulder with its sand dump and slime dams.

FIG. 9.—BROKEN HILL PROPRIETARY, BLOCK 10, OLD SLIME DAM IN RIGHT FOREGROUND

FIG. 10.—BLOCK 10, OLD V-SHAPED SLIME SETTLERS AT RIGHT AND FORMER ELMORE PLANT AT LEFT

Corrugated Galvanized-Iron Agitator Tanks.

The settler-agitator tanks shown in Fig. 14 are at the Brown Hill mill, and are of special interest from the viewpoint of construction. They are built of corrugated galvanized iron, and were erected about 14 years ago to meet an urgent demand for an increased agitating capacity.

They were designed only for temporary use until steel tanks could be built, but have remained in service all these years, much to the surprise of all concerned. Each tank is provided with a derrick for raising and lowering the agitating mechanism. The latter being raised, the dilute slime pulp is run into the tank as long as a reasonably clear overflow is obtained.

The slime is then allowed to settle, and the clear solution is siphoned off, after which the agitators are started and gradually lowered into the thickened slime. The same type of agitator is shown in the foreground of Fig. 13, which is a small plant operated by the Lake View Company, for the retreatment of slime.

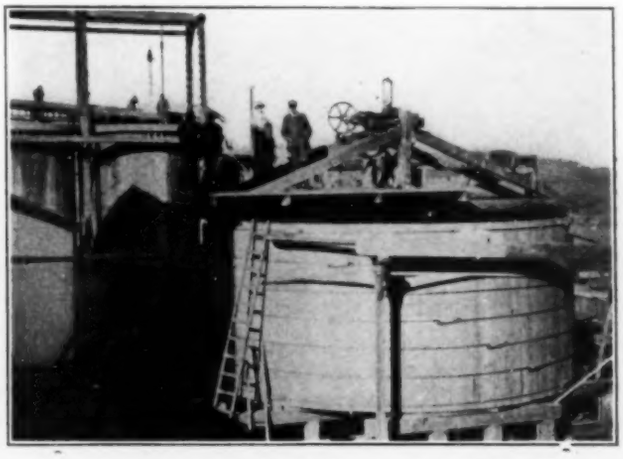


FIG. 11.—BLOCK 10, FIRST DORR CONTINUOUS THICKENER ERECTED AT BROKEN HILL. SAND TANKS AT LEFT

Retreatment of Old Slime.

It is significant of the progress of metallurgy in Kalgoorlie, particularly in the treatment of slime, that old accumulations of this material which formerly could not be handled, are now being treated profitably. Two methods of reclaiming these old slime dumps are shown in Figs. 15 and 16.

At the Lake View, Fig. 15, a train of cars is run onto a track laid along the edge of the dump. Chutes of galvanized iron are laid from the cars to the dump, so that the solid slime dislodged from the top will find its way into the cars. When the angle of inclination becomes too small for the slime to run well, the dump is undercut and the track moved into a new position.

A different method is adopted at the Golden Horseshoe, Fig. 16, the slime being mixed with cyanide solution at the dump and pumped to the mill. The machinery consists of a portable truck on which is mounted a triplex pump, vortex mixer, motor and belt conveyor. The dry slime is barred down onto the conveyor which delivers it to the mixer beneath the pump.

FIG. 12.—AMALGAMATED ZINC COMPANY, LTD., USING DE BAVAY FLOTATION PROCESS

Here it is mixed with cyanide solution piped from the mill, and then pumped back into the agitators. The position of the truck is changed from time to time as the dump is removed.

Spitzkasten with Inclined Baffles.

About two years ago an interesting device for slime thickening was built at one of the large gold mines in Western Australia.[1] Experiment had apparently shown that a marked increase in the rate of settlement and density of pulp could be obtained in spitzkasten containing a number of inclined baffles placed near the surface of the slime. Accordingly several large spitzkasten were built and thus equipped; but evidently the net result was not satisfactory, for the device was abandoned in favor of continuous mechanical thickeners.

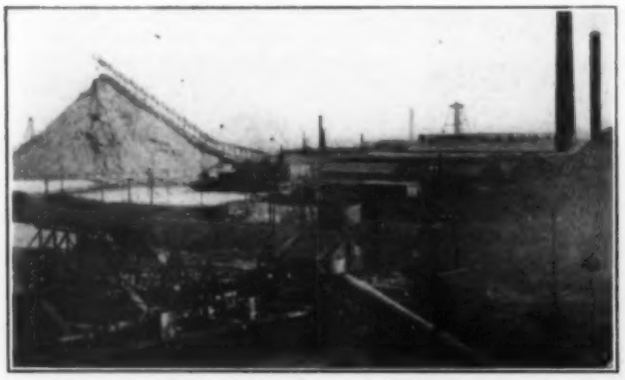


FIG. 13.—GREAT BOULDER SAND DUMP AND SLIME DAMS IN BACKGROUND. LAKE VIEW SLIME RETREATMENT PLANT IN FOREGROUND

FIG. 14.—CORRUGATED GALVANIZED AGITATOR TANKS AT THE BROWNHILL MILL

[1]See this journal, September, 1911, p. 467.

The Perseverance mill, Fig. 17, is the latest to be built at Kalgoorlie, having been rebuilt following the destruction by fire of the old plant about 2½ years ago. The principal steps in the process are dry crushing, roasting and cyaniding. Separation of sand and slime is made in pointed boxes, the slime being dewatered in cones.

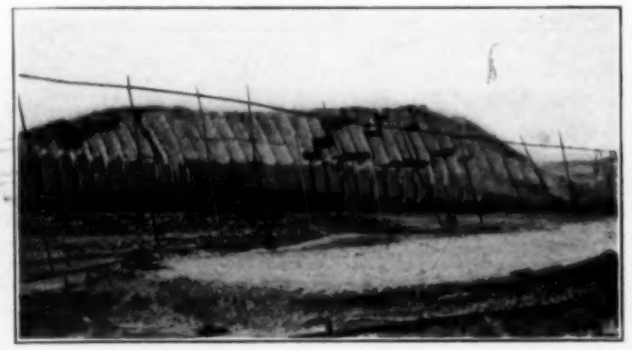


FIG. 15.—RECLAIMING OLD SLIME DUMP AT THE LAKE VIEW, KALGOORLIE

Gold Milling in New South Wales.

About 500 miles west of Sydney is the Cobar goldfield where metallurgical operations are conducted on a large scale. The Great Cobar copper mine is located here, and copper smelting has been carried on for a number of years. The Cobar company owns also several other properties, at one of which, the Cobar Chesney, copper-gold ore is produced. A 500-ton concentrator has been built, equipped with rolls, Hancock jigs and Chilean mills for regrinding.

FIG. 16.—RECLAIMING OLD SLIME DUMP AT THE GOLDEN HORSESHOE, KALGOORLIE

The ore is ground to pass 30-mesh screen, and dewatered in Dorr continuous thickeners to a consistency of 3½ parts liquid and 1 part solids, in which condition it is treated for the recovery of copper by the Minerals Separation process. The tailings contain practically all the gold, and today it is planned to build a cyanide plant to treat them.

FIG. 17.—PERSEVERENCE MILL, KALGOORLIE

The Cobar Gold 100-stamp mill, another property of the

Cobar company, treats a gold ore containing a little copper. A view of the plant, which was built a few years ago, is given in Fig. 18. It was designed to employ the Elmore vacuum flotation process for the removal of copper, with subsequent cyanidation of the tailings. The process was unsuccessful and

FIG. 18.—COBAR GOLD MILL, NEW SOUTH WALES

the plant was closed. Today it is proposed to install Minerals Separation flotation, which has been found to yield a tailing amenable to cyanidation.

Fig. 19 gives a view of the stamp mill of the Mt. Boppy mine, located about 50 miles east of Cobar. The Mt. Boppy is today

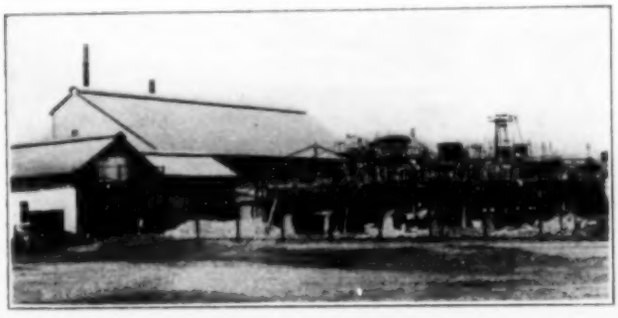


FIG. 19.—MT. BOPPY GOLD MILL, OLD SHALLOW LEACHING TANKS IN FOREGROUND

the premier gold mine of New South Wales, and the mill is the most modern in Australia. Reconstruction of the plant was in progress at the time the photograph was taken. The only feature of the ore treatment which may not seem to be in accord with modern cyanide practice is that the ore is crushed in water and not in cyanide solution. The explanation of this

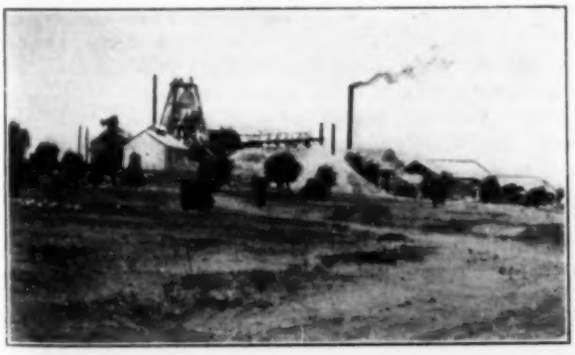


FIG. 20.—OCCIDENTAL MINE AND MILL, COBAR, NEW SOUTH WALES

step is found in the fact that the ore is sufficiently acid to require a preliminary wash, which is best accomplished by crushing in water.

Some of the shallow leaching tanks in the foreground of Fig. 19 have been dismantled and converted into Dorr thickeners of twice the depth. A preliminary dewatering is accomplished in these machines, following which the final dewatering is done in a Moore filter. The discharged cake is then mixed with cyanide solution and agitated in concrete Pachuca tanks, after which it is finally filtered in another Moore filter. In this connection it is interesting to note that the Pachuca, or Brown, agitator is rarely seen in Australia, various forms of paddle agitators being generally used.

Still another important mill in the Cobar district, which has been reconstructed during the past year to conform to modern practice, is that of the Occidental company, shown in Fig. 20. The present equipment consists of stamps, card tables, tube mills, Dorr classifiers and continuous thickeners, Pachuca agitators and Moore filter.

Denver, Colo.

The Chemistry of Tungsten*

By Chas. Baskerville, Ph.D.

The classification and mechanical concentration of tungsten ores are relatively simple because of the high gravity of all tungsten compounds. However, the hydro-mechanical processes are insufficient to ensure complete separation of cassiterite, it being necessary, when this mineral is associated with the ore, to resort to magnetic separators.

There are a number of forms of apparatus used for the concentration of tungsten ores, such, for instance, as the separators of Mechernich, Johnson, Wetherill, Rowand, Knowles and King. A notable feature in tungsten ore milling is the large table area required per ton of ore treated, which reduces the tonnage capacity, according to experience in Colorado. Screen sizing has not been practiced in this country on a large scale, with a view of eliminating coarse material which might prove worthless; and it has been suggested that this procedure as well as classification be more widely considered.

The Chemical Treatment of the Concentrates.

The chemical treatment of the mechanical concentrates and the production of tungstic acid are based upon the following general principles:

(1) The alkaline carbonates attack in the dry way insoluble tungstates to form soluble alkaline tungstates.

(2) Mineral acids precipitate tungstic acid from tungsten in solution in a form insoluble in the solution.

(3) Ammonium tungstate is decomposed at redness in an oxidizing atmosphere into tungstic acid.

(4) Tungstic acid and tungstates are attacked by hydrochloric acid gas, forming the oxy-tetrachloride, easily volatile and decomposed by water into tungstic acid and hydrochloric acid.

(5) Solutions of alkaline tungstates are transformed into sulphosalts by the action of hydrogen sulphide. On decomposing the sulpho-tungstate with a dilute acid, the only slightly soluble tungsten trisulphide is formed.

Wolframite may be attacked by aqua regia, alkaline carbonates, or bisulphates. Decomposition by alkaline carbonates is the one generally used in the tungsten industry. The wolframite is fused, after pulverization, with sodium carbonate with the addition of nitrate. The fusion is done in a reverberatory furnace usually on a hearth of dolomite agglomerated with tar and burned in place. After the fusion the mass is broken up, digested with water in filter tanks with methodic washing; nearly boiling water is employed, and the alkaline tungstate dissolves along with silica and phosphoric acid as silico-tungstate and phospho-tungstate of sodium. The metallic oxides remain in the residue.

Hydrochloric acid is then added to the solution in a boiling state to aid reaction, when the neutral tungstate passes to the form of para-tungstate, $5Na_2O.12WO_3$, soluble in hot solution, but precipitated in the cold. The silico-tungstate and phospho-tungstate of sodium are more soluble and remain in the mother liquid. The para-tungstate is filtered off, washed and transformed back again to the normal tungstate by the addition of sodium hydroxide. Tungstic acid is then obtained from this solution by the addition to it, when boiling, of hydrochloric acid.

The objections to this process are that large quantities of reagents are necessary and that there are considerable losses on

*Extracts from a lecture delivered before the New York Electrical Society in the Chemistry Bldg. of the College of the City of New York. The lecture was profusely illustrated. The introductory chapters on the history of tungsten metallurgy, the production of tungsten ores, and geochemical considerations are here omitted.

account of the slight solubility of the precipitates. Therefore, Jean suggested heating with calcium carbonate and sodium chloride—a process applicable only to a very pure wolframite, since chloride silica is not eliminated; Gin heats to 1200-1300 deg. C. with magnesium chloride or fusion with potassium bisulphate (insoluble potassium acid tungstate is thus formed); while the Kempen Electrochemical Company heats sodium bisulphate to fusion with mono-hydrated sulphuric acid, then introduces the pulverized mineral. These processes are cited in passing only as examples.

Tungstic acid may be prepared from scheelite by decomposition with concentrated hydrochloric or nitric acid, forming chloride or nitrate of calcium in solution, and an insoluble residue containing tungstic acid; by fusion with potassium fluoride, producing soluable alkaline tungstate and insoluble calcium fluoride; or by conversion of tungstic acid into oxy-tetrachloride, $WOCl_4$, which boils at 227 deg. C., by means of ferric chloride, and then decomposition of this compound by means of water to form tungstic acid and hydrochloric acid.

The Preparation of Tungsten

Metallic (elementary) tungsten may be prepared by a variety of methods; as, for example:

(1) By reduction of tungsten trioxide (tungstic acid) by means of hydrogen.

(2) By heating the hexachloride in hydrogen.

(3) By heating the trioxide with carbon, in, say, an electric furnace.

(4) By heating the nitride.

(5) By heating to redness a mixture of ammonia tungstate or the trioxide with metallic zinc.

(6) By the passage of an electric current in vacuo through filaments of an amalgam of tungsten, cadmium and mercury; cadmium and mercury are expelled, while the tungsten is left.

Still other processes are the aluminothermic method, reduction with magnesium, reduction with phosphorus, electrolysis of the double chloride of tungsten and sodium, and by heating tungsten silicide with lime.

Cast tungsten may be prepared in the electric furnace by direct treatment of tungsten trioxide with carbon; reduction with calcium carbide in the presence of silica (not used industrially because the sulphur and phosphorus present are retained by tungsten carbide); or by reduction with ferrosilicon.

Sometime ago I made, during the course of an investigation of tungsten filaments for electric incandescent lamps, a study of the reduction of tungsten trioxide by means of carbon. Lack of time will only permit me to present the conclusions:

(1) When metallic tungsten, obtained by the reduction of tungsten trioxide with carbon, is heated with carbon, the exterior portions of the metal contain carbon.

(2) When metallic tungsten, obtained by the reduction of tungsten trioxide with carbon, is heated with an excess of carbon, the metal readily forms a definite carbide, W_2C, which possesses much the same properties as the metal, but is more easily attacked by reagents.

(3) When a metallic compound serving as a solvent is present, the chemical action is moderated by dilution and the combination of carbon and tungsten occurs at lower temperatures, W_2C in all events resulting on heating to a higher temperature.

(4) When pure tungsten trioxide is mixed with carbon and then heated, to effect reduction to the metallic state, a carbide-free tungsten can only be obtained when the quantity of carbon used is insufficient for complete reduction and the temperature employed is below the melting-point of the metal. When tungsten trioxide is heated with an excess of carbon, or in a carbon crucible, the carbide W_2C results; the carbon in excess of that required by the formula is given up as graphite on cooling; and this graphitic carbon may be burned off.

These conclusions, based upon the work of Moissan, Williams, Carnot and Goutal, Lebeau, Greenwood, Borchers, and Defacqz, as well as upon observations of my own, are of considerable practical importance to illuminating engineers, for they naturally lead to the inquiry, "Do not the commercial preparations, obtained by the reduction of tungsten trioxide with carbon, and especially tungsten filaments for incandescent electric lamps, formed by heating tungsten with a carbonizable agglutinant, contain tungsten carbide, W_2C?"

The physical properties of hard, brittle tungsten—the variety found in commercial lamps before the advent of the new Mazda lamp, and which were completely lacking in ductility and pliability, and were brittle and difficult to obtain with a permanent set—and those of pure ductile tungsten remind one of the differences between the tantalum of Berzelius and Moissan and that of von Bolton, since the admixture of carbon with tantalum was ascertained to explain the differences between the observations of the latter and those of his predecessors; and the comparison of non-ductile tungsten with hard and brittle tantalum becomes more relative when it is indicated that their respective atomic weights are 184 and 181.

The Manufacture of Metallic Tungsten and Ferro-Tungsten

For the manufacture of tungsten and its alloys on an industrial scale, especially for employment in the steel industry, the raw material is usually a concentrate containing from 60 to 70 per cent of tungsten trioxide. This is mixed with sodium carbonate (soda-ash) and is then roasted for about four hours; it is now treated in a dissolver, filtered, concentrated, and allowed to crystallize. Upon filter-pressing, the sodium tungstate remains in the press, and the mother-liquor is conducted into a vat for further treatment. The proper amount of hydrochloric acid is added to precipitate the yellow oxide, which, after drying, is reduced to powder metal of 99.25 to 99.50 per cent. purity, with a carbon content of 0.50 to 0.15 per cent and a density of from 19 to 19.25.

In the production of ferro-tungsten, the concentrates are often mixed with the proper proportion of steel, rod graphite, and a secret compound to assist reduction and fluxing, and the crucibles are placed in a gas-fired crucible furnace and smelted for several hours at a high heat. While, however, an 80 to 85 per cent tungsten alloy may be made by heating the powdered metal with low-carbon steel scrap in the crucible furnace, yet the higher-grade alloys, such as 85 per cent, are manufactured in the electric furnace directly from the concentrates and steel.†

The Uses of Some Tungsten Compounds

Tungstic oxide has been used as an oil and water color.

Large quantities of sodium tungstate are manufactured, much of which is used in fireproofing cloth for curtains and draperies, and as mordant in dyeing.

Other tungsten salts are used in weighting silks. When silks are dyed, tungsten salts, owing to their high specific gravity, are introduced to give more apparent weight to the fabric.

Sodium tungstate has almost exactly the same rate of expansion for moderate temperatures as platinum, so that it is used for sealing platinum apparatus.

Calcium tungstate, on account of its fluorescence, is used as a screen to make X-rays visible.

Tungsten compounds have also been used in glass and porcelain coloring, and in making certain bronze powders. Tungsten bronze is made by dissolving tungsten trioxide in melted sodium tungstate; the goldlike leaflets are used as a pigment. There is also a violet tungsten bronze; $K_2W_3O_9$ mixed with W_2O_5.

Sodium phosphotungstate is used as a reagent for alkaloids. Cadmium borotungstate (sp. gr. 3.28 is used for the mechanical separation of minerals). Lead tungstate has been substituted for white lead in paints.

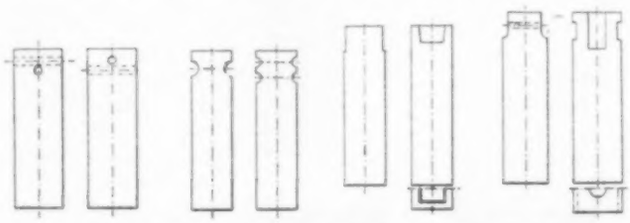
College of the City of New York.

†In Dr. Baskerville's lecture then followed chapters on the properties of tungsten, the compounds of tungsten, and the uses of tungsten for making special steels and tungsten alloys and a very extensive chapter on the manufacture of tungsten filaments for electric incandescent lamps. An interesting account was given of some analyses of tungsten filaments carried out by Dr. Baskerville in which the composition of the filaments was to be determined and enough to be saved to serve as corpora delicti. The total weight of one of these filaments was a little over 2 milligrams. The filaments proved to be tungsten. Then followed a chapter on the uses of tungsten for crucibles, electric furnace resistors, gauge, Roentgen tube targets, thermoelements, etc.

Electrode Holder Construction for Electric Furnaces

A Description of the Principal Types of Electrode Holders for Furnaces, with Additional Notes on Joining and Dimensioning Electrodes

The issues No. 12 and 14 of March 20 and April 3, 1913, of *Stahl und Eisen* contain a very thorough and useful digest of the problem of proper construction of electrode holders, with additional notes on the joining of electrodes and the dimensioning of electrodes, from European electric-furnace practice. We herewith give a translation of this article practically in full.



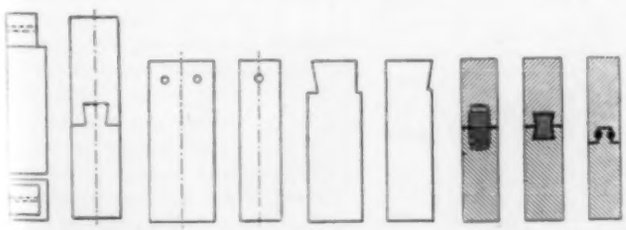
FIGS. 1 TO 8.—USUAL ELECTRODE CONSTRUCTIONS

The holders in use are either topholders (Kopffassungen) or sideholders, pressing against the sides of the electrodes and allowing a feeding of the carbons, while the holders themselves remain in place.

In topholders the same contact surface is maintained between holder and electrode until the latter is used up. Topholders are almost exclusively used in the manufacture of carbide, ferrosilicon and aluminium, while in electric steel furnaces sideholders are usually employed.

Good electrodes are generally too hard for machining. Special shapes, therefore, which are often called for by the user are made by forming the material before it is baked. Figs. 1 to 19 show a number of the ordinarily used shapes of electrode ends. The recesses provide for either a good contact with the cable or for joining the ends of electrodes together so as to avoid waste.

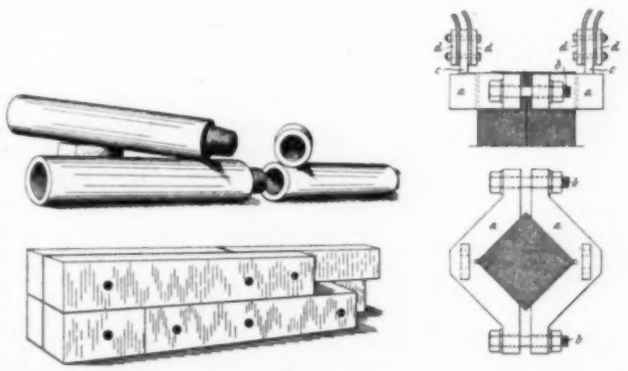
That the proper construction of the holder and the contact is of great importance as it affects the electrode consumption and the cost of maintenance has been recognized by most manufacturers. This has led to quite a variety of constructions. The current-conducting parts are mostly made of copper or bronze, while those parts which press the contact surfaces against the electrodes are made of wrought iron, steel or steel



FIGS. 9 TO 14.—USUAL ELECTRODE FORMS. FIGS. 15 TO 17.—JOINING ELECTRODES

castings. A current density of 3 to 5 amperes per sq. cm. (19 to 32 amp per sq. in.) is usually adopted for these contacts, the lower limit being preferred.

The surface condition of the electrode is of particular importance where a good contact is wanted. The surface of the carbon should be as flat and hard as possible and be cleared from coal or flue dust before putting the holder on. Elastic layers of copper netting or thin iron sheets are useful in improving the contact. Unfitted holders often cause trouble as the electrode may become red hot inside or below the holder causing it sometimes to break or resulting at least in an excessive amount by burning. Since the ohmic resistance of carbon decreases with increasing temperature, the current will pass preferably through the hot parts of the electrode, and thereby make the evil worse.



FIGS. 18 AND 19.—JOINING OF ELECTRODES. FIG. 20.—HOLDER FORMERLY USED WITH CARBIDE FURNACES

The following figures from Louis, Les Electrodes en Carbone et Leur Emploi dans les Fours Electriques (*Bull. Techn. de la Société des Anciens Elèves Des Ecoles Nationales d' Arts et Metiers*, 1910, No. 2, p. 244) illustrate the influence of the holder on electrode consumption and maintenance cost. In a large plant producing 4000 tons of ferroalloys per year the cost of maintenance of the holders was marks 6.40 ($1.60) per ton of metal produced or marks 25,600 ($6,400) per year. By using an improved holder this cost was reduced to marks 1.60 ($0.40) per ton, saving marks 19,200 ($4,800) annually. The consumption of electrodes was also reduced resulting in an additional saving of marks 12,800 ($3,200). The total saving due to the use of an improved holder was, therefore, marks 32,000 ($8,000) per year, or marks 8 ($2.00) per ton of product.

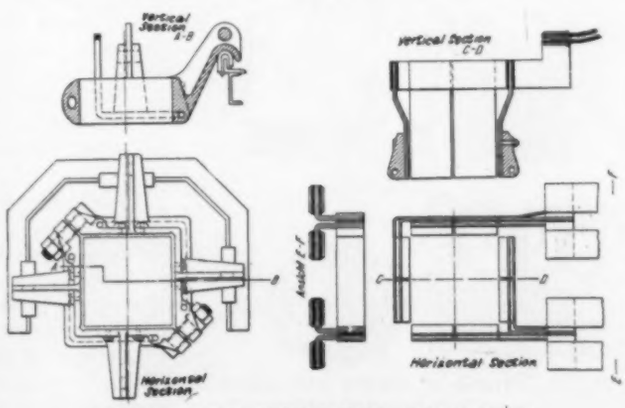


FIG. 21.—HOLDER WITH COOLING ARRANGEMENT

Topholders

In carbide plants the connection of Fig. 20 was formerly often used consisting of two solid V-shaped cast-iron clamps *a* tightened by bolts *b* and connected to the cables by means of necks *c* and pressure plates *d*. This solid electrode holder never proved satisfactory. When the electrode became short the holder became hot and the electrode was hot too and the cast-iron pieces often melted. Later on a cooling device was combined with this construction shown in Figs. 21 and 22.

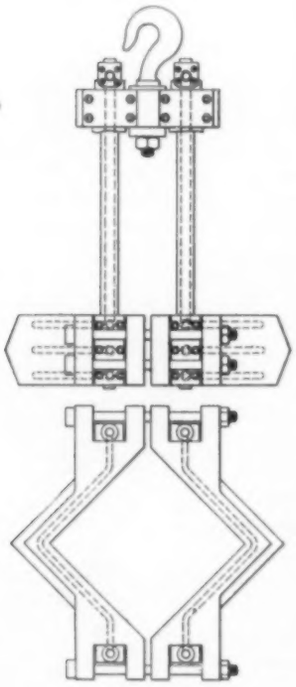


FIG. 22.—HOLDER WITH COOLING ARRANGEMENT

Fig. 23 represents a connection which has proved satisfactory in a carbide furnace.

The head of the electrode is dove-tailed and clamped between two cast-iron plates *b* by means of two wedges, *a*. The whole apparatus is supported by an iron structure, which itself hangs on an electrically insulated hook. Copper plates *d*, *e* and *f* serve to make contact at *h* with the flexible laminated ribbons *g*, carrying the current. The mechanical suspension is independent of the electric connection and the weight of the electrode tends to tighten the contact between copper plates and electrode head. An electrode equipped with this holder can be put into service very quickly by hooking into the chain of the windlass, and making contact at *h*.

The holder, shown in Fig. 24, has been successful in the manufacture of ferroalloys. The electrode consists of four carbon blocks embedded in a tamped carbon mixture. Two opposite surfaces of the same block have dove-tailed recesses in order to clamp the copper plates *a* by means of the screwbolts *b* and the plates *c*. This holder is simply connected to the plates *d* of the current leads *e*. The plates *a* preferably consist of copper, the plate *c* of steel casting, the pressure screws of iron with square thread, and the plates *c* of bronze or of cast iron containing manganese.

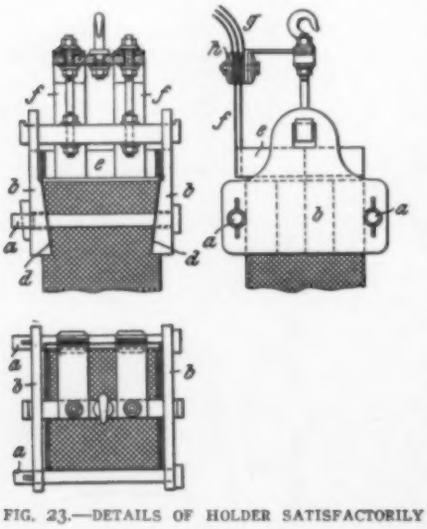


FIG. 23.—DETAILS OF HOLDER SATISFACTORILY USED IN CARBIDE FURNACE

If the surface of the dovetails is not smooth enough to secure a good contact, the heating at the contact will be avoided by putting a cushion of very fine strands of a copper cable between the carbon and the copper plate. Under the pressure of the screws, this cushion of about 0.5 cm. (3/16 in.) thickness is pressed into the rough spots of the carbon and secures the passage of the electric current under favorable conditions.

When the electrode butts are to be utilized down to a length of 50 cm. (20 in.) it becomes necessary to cool the parts artificially to prevent the holder from being destroyed by the heat of the furnace. Fig. 25 shows the copper plates of the current lead being wedged to the carbon by means of water-cooled channels *a* open at the top. This design has given good results especially in furnaces with an open hearth.

The holder shown in Fig. 26 is good for cylindrical electrodes. The flexible leads are fastened to a bronze piece *a* of special form. This piece is fastened to the carbon by an electrically insulated ring and has a contact surface machined on the lathe. The holder itself is a box *c* surrounding the head of the electrode and pressed to the piece *a* by the screws *b*. After loosening the screws *b* the pieces *a* and *c* can be taken apart by a quarter turn. The piece *c* which is protected by the iron sheet *d* is put on top of the electrode, and bronze *e* is poured into the free space between the box and the carbon and on top of the electrode.

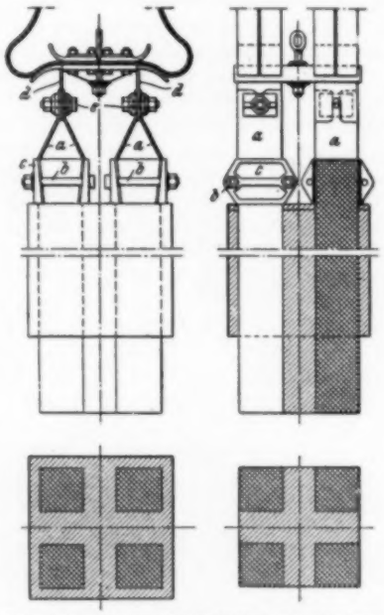


FIG. 24.—ELECTRODE HOLDER SATISFACTORILY USED ON FERROALLOY FURNACE

The weight of the electrode produces an excellent contact between the bronze and the walls of *c*. The holder is cooled with water which enters through *f*, and drops through the central overflow pipe onto the top of the electrode; the admission of water is regulated to make up for evaporation.

Fig. 27 shows a holder cooled by water under pressure. The ring-shaped piece *a* is hollow in the center, the water circulating through *b*. Copper sheets *c* serving both as mechanical suspension of the electrode and as current leads, are pressed against the electrodes with cast-iron or bronze wedges *d*. The wedges have regulating screws and piece *a* is held by four pressure screws.

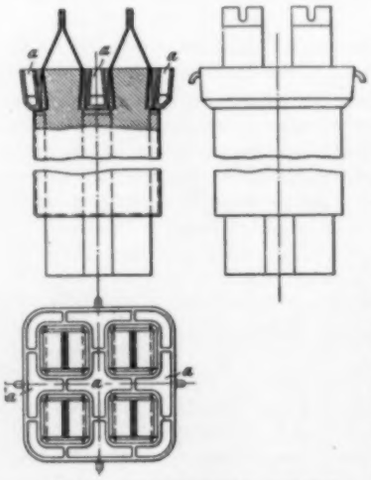


FIG. 25.—WATER-COOLED HOLDER

While an intimate contact is hard to make between a carbon electrode and the cable, it is easily obtained between the cable and a metallic electrode by screwing the poleshoe at the end of the cable to the electrode. The contact surfaces of the poleshoe and of the electrode can be ground into each other, which warrants a good contact on the entire surface. As it is hardly ever possible to get the surface of a non-metallic electrode perfectly plane there will always be a certain contact resistance and evolution of heat and it may be necessary to remove this obnoxious heat of the contact by special contact-cooling devices.

The Westdentsche Thomas Phosphatwerke have a German patent (No. 207,361) for the construction shown in Fig. 28. The square-shaped electrodes *a* have a recess on top and a copper cap *c* is dumped over this head. In order to make good

contact where the surfaces do not touch each other, the cap is filled with liquid aluminium or another metal of similarly high melting point and while the aluminuim is still liquid a red hot wrought iron ring *e* is shrunk round the copper cap. During the simultaneous gradual cooling of the aluminium and the iron ring a very close contact is produced between the copper cap, the aluminum layer and the top of the electrode.

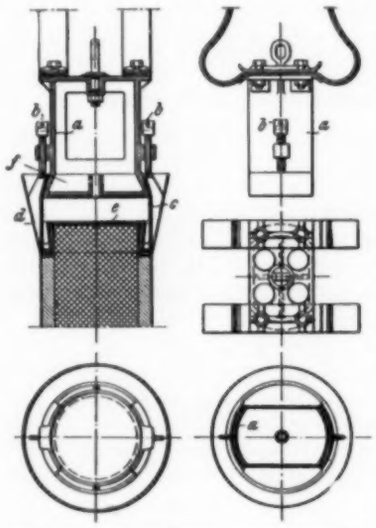


FIG. 26.—HOLDER FOR ROUND ELECTRODES

Contact resistances cannot show up any more. The poleshoe *f*, the screws *g*, the hoops *h* and the cable ends *i* can be seen from the figure. As no soldering is required in this whole design, an important source of trouble has been eliminated.

With the holder constructions described so far, the remaining butt of the electrode, which is about 50 cm. (20 in.) long in furnaces with an open hearth, is not used up. In furnaces with arches, as for instance in electric steel furnaces, the discard is larger, leaving a butt of about 90 cm. (36 in.) which means that only about one-half of the electrode can be used.

Movable Side Holders

In order to utilize completely the electrode material, movable holders are employed which allow the electrodes to slide through. The electrode is not held on one end, but somewhere between its two ends connection is made to the cable; when a piece of electrode is used up, another piece of carbon is added to the previous piece, and the holder raised accordingly.

Fig. 29 represents this type of connection in a design proposed by Louis. The electrode is held between two hollow pieces of metal *a* which form a pair of tongs. The tongs are pressed against the electrodes by the screw *b*. When the lower part of the electrode is consumed, it can be fed downward for the desired length. The cable is fastened at *c*; the best way of cooling the pieces *a* and the contact is by means of water under pressure.

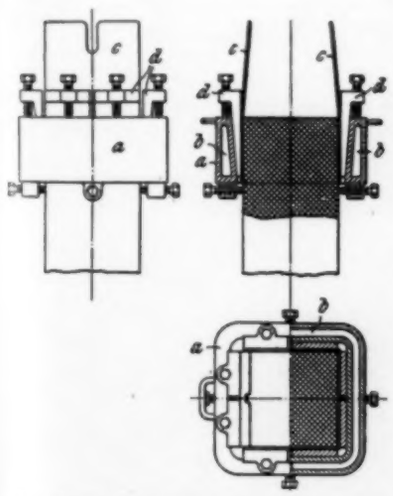


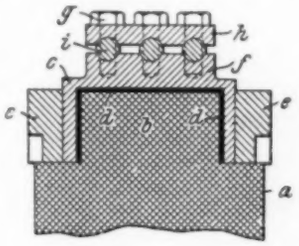
FIG. 27.—HOLDER COOLED WITH WATER UNDER PRESSURE

Fig. 30 shows another tongs design for a combined electrode of several blocks. The carbon blocks are pressed by steel levers by means of the screws *a* against the central piece of bronze, which serves as suspension and current lead.

Fig. 31 shows a similar design in which adjustable wedges are employed which are water-cooled.

The holders of most electric steel furnaces are built for complete consumption of the electrode material and have been repeatedly shown to our readers.

In the Heroult furnace each electrode is held by a bracket from a vertical rack, which is moved up and down by gear and pinion. Each carbon is surrounded by a band of metal, pieces of copper being inserted, which carry the current from the cables.



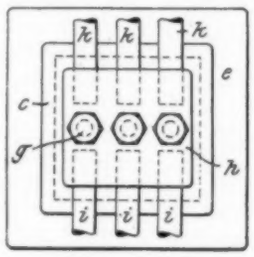


FIG. 28.—CONSTRUCTION OF WESTDENTSCHE THOMAS-PHOSPHATWERKE

Figs. 31, 33 and 34 show various constructions used by Girod (for round electrodes), the Aktiebolaget Elektrometall Ludwika, and by Nathusius (side plates).

Joining of Electrodes

The joining of two electrodes is mostly accomplished by thread and screw, as shown in Fig. 15. Various other possibilities for making the joint are illustrated by Figs, 10, 16, 17 and 18.

The process of joining requires the use of specially shaped pieces, threadings, etc. All these cause a number of difficulties. These are overcome by the firm of Siemens Bros. & Company, by molding cylindrical, conical, or otherwise shaped recesses around the end of the electrode, as represented in Figs. 35 to 37, and as known to our readers from the description of U. S. Patent 1,049,624 on page 217 of the April issue of METALLURGICAL AND CHEMICAL ENGINEERING.[1]

The joint also causes a certain loss of voltage. This loss has been found to be 2 to 2.5 volts for square electrodes of 280 to 300 mm. (11 to 12 in.) side length with a current density of 5 amp per sq. cm. (32.25 amp per sq. in.). This would mean a drop of from 4 to 5 volts for an electric steel furnace with two arcs in series, or a loss of 16 to 20 kw. for a 500-kw. load, which represents 3.5 to 4 per cent of the total energy.

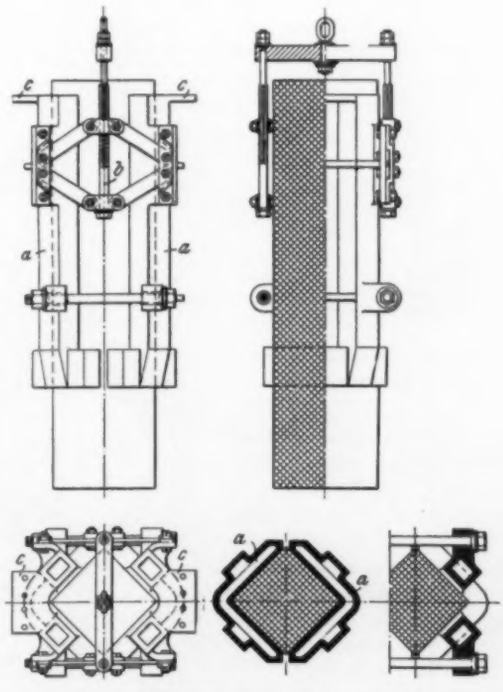


FIG. 29.—CONSTRUCTION WITH MOVABLE CONTACT

[1]Concerning the method of joining employed by the National Carbon Company, of Cleveland, see the paper of Fitzgerald & Hinckley in our May issue, page 279.

But it seems not impossible to reduce this loss in the future.

The drop of voltage is caused by three circumstances:

(a) The contact resistance between electrode and nipple. It can be reduced by accurate machining of the contact surfaces.

(b) The contact resistance between the two electrodes; it will be small when absolutely plane faces of the carbons are employed. A good electrode paste is useful.

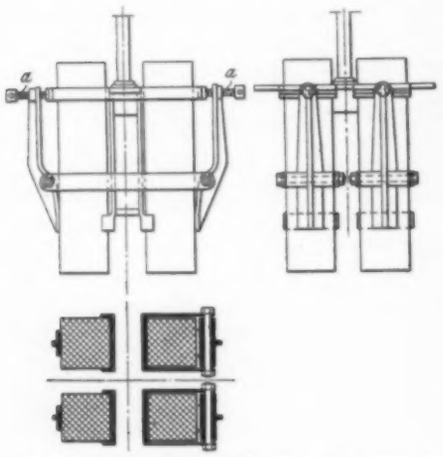


FIG. 30.—HOLDER FOR ELECTRODE CONSISTING OF SEVERAL BLOCKS

(c) The resistance of the nipple; it can be decreased by the proper choice of material. Formerly these studs were made of the same kind of material as the electrode. According to a suggestion of the *Planiawerke* (German patent 238,343) the contact resistance at the joints is considerably lowered, if the nipple is made of a material which conducts the current better than the material of the electrode, such as a mixture containing graphite or metal.

It has also been proposed to make these connecting studs from metal. This, however, would defeat the special purpose of these studs. They would melt and volatilize and not fill their purpose since their object is to use the last piece of the electrode. This latter aim is completely reached by a joint containing small particles of metal embedded in carbon.

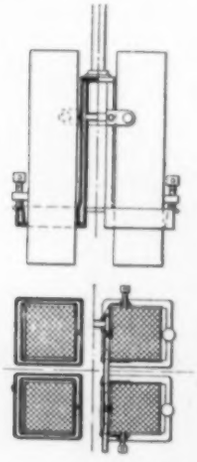


FIG. 31.—MODIFICATION OF DESIGN OF FIG. 30

The disadvantages of this method are as follows:

1. The manufacture of the accurate inner thread and nipples and other shapes increases the cost of the electrode construction.

2. The contact resistance causes losses of energy.

3. The joint is apt to loosen and to increase these losses or the end of the electrode in the furnace may drop off causing short circuits or other troubles; too tight a joint might result in a breaking of the two carbon pieces. (Borchers, Elektrische Oefen, 2nd ed., p. 143.)

These difficulties are unknown in the use of electrodes which are not joined together; it is mainly a matter of calculation whether to join electrodes or not, and the cost of power, the cost of electrodes, and their length will decide which of the two methods should be used in any case. In cases in which the furnace and the holder allow to use the electrode down to but a small stump it will be in many cases more advisable not to join the electrodes.

Metallic Conductors in Electrode Heads

Keller's method of inserting the metallic conductor into the head of the electrode gives satisfactory results. This method has been known for some time. With small electrodes the connection to the current leads is obtained by means of metallic plates placed between the conductor and the carbon (Borchers, l.c., p. 149, Fig. 235). But too close a tightening of the bolts often causes the electrode to crack while otherwise the contact may be poor.

Fig. 38 shows an electrode connection often used for the manufacture of aluminium. The end of a flat piece of iron is upset in the shape of a fishtail and then molded into the electrode. Plants who manufacture their own electrodes insert this connector before baking, whereas those who buy them baked fasten the metal with a graphite mortar or by pouring liquid bronze into the hole.

Fig. 39 shows a connection made by a screw bolt. A thread is made in the end of the electrode and an iron rod, threaded at one end, is fastened in the same. A mantle of bronze or aluminium bronze forms contact at both ends and secures the passage of current. Four or six of these electrodes are sometimes combined in aluminium furnaces as shown in Fig. 40.

A connection of Dr. Lessing, of Nuremberg, (German patent 211,273) is shown in Fig. 41. It consists of a piece of iron molded with the electrode which has square-shaped threads of such an angle that the distance *b* between the threads is considerably larger than their thickness *a*. This bolt can be removed from the carbon before baking without destroying the threads in the latter. The iron piece *d* connects with the threaded bolt *c*. By screwing the bolt into the carbon and

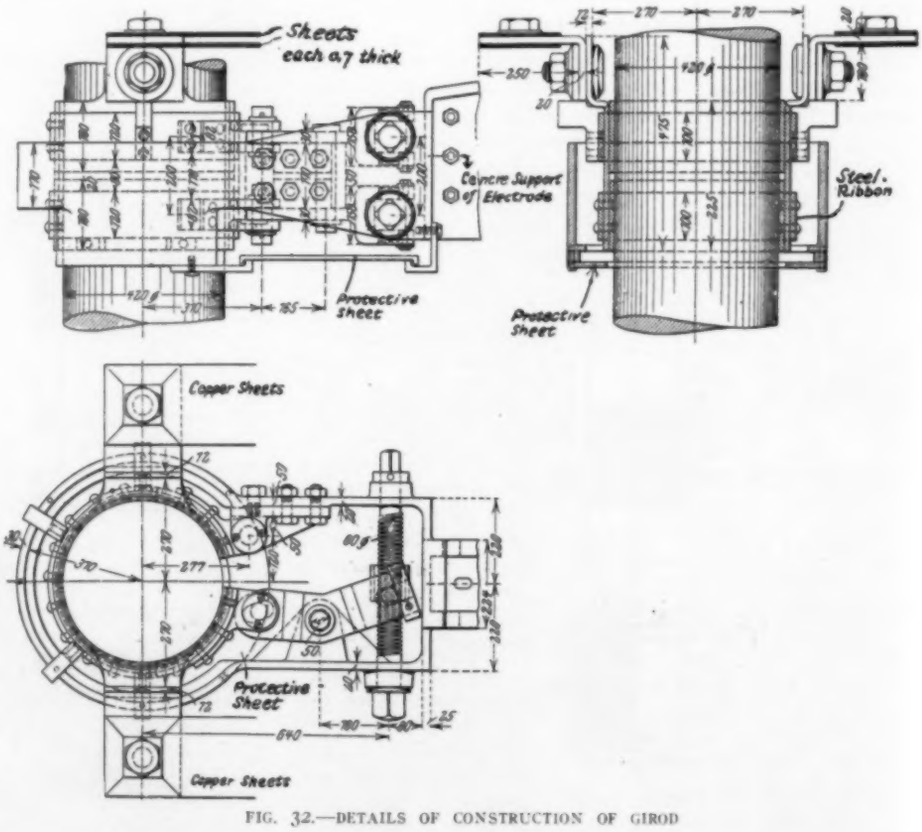


FIG. 32.—DETAILS OF CONSTRUCTION OF GIROD

securing it by a counternut e an excellent contract is obtained.

Keller, Fig. 42 (German Patent 218, 054), allows the metallic conductor a certain play, the lower end being tapered thicker into the hollow top of the carbon. Liquid metal, copper or pig iron is then poured into the space left in between. This produces a mechanically and electrically reliable contact. No

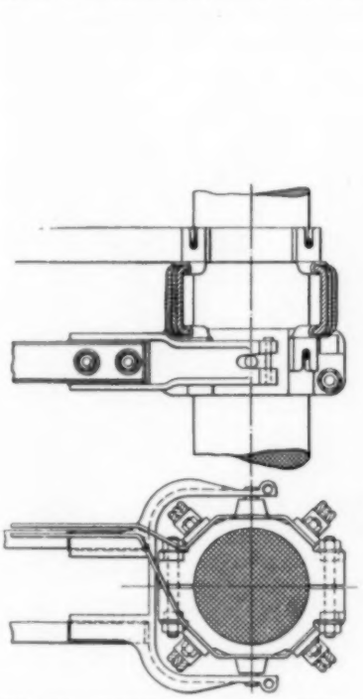


FIG. 33.—CONSTRUCTION OF AKTIE-BOLAGET ELEKTROMETALL LUDVIKA

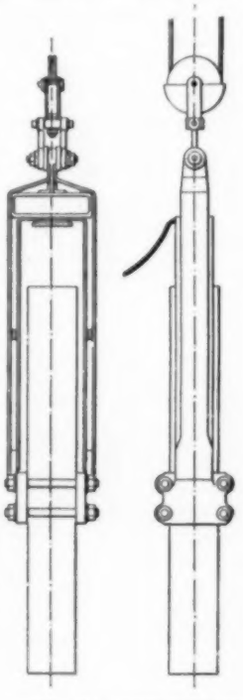
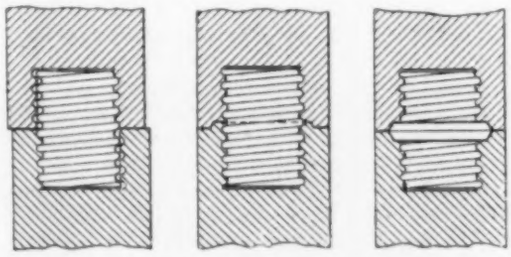


FIG. 34.—CONSTRUTION OF NATHUSIUS

jaws, wedges or screws are required to make or improve the contact. The interior of the metallic conductor is intensely water-cooled in order to utilize as much length of the electrode as possible.

The metal has to be poured carefully into the open gap between conductor and carbon. The cavity in the electrode is first heated by a piece of red hot iron, the preheated current-conductor is then introduced and kept about 5 mm. (0.2 in.) distant from the bottom of the cavity by a small hard body. Very hot bronze or cast iron is then poured in.

Although the metal shrinks a little it makes an intimate contact. The effect of shrinkage can be entirely overcome by casting about 30 grams of tin around the contact metal after it has cooled. If the contact should not be perfect it heats up when the electrode is put to use, the tin melts and flows into the interstices and makes a perfect contact. The costs of this



FIGS. 35 TO 37.—JOINING OF ELECTRODE. FIG. 35 SHOWING THE WRONG WAY, FIGS. 36 AND 37 CORRECT METHODS

method are said to be low. The contact metal and the tin can be recovered after the electrode has been consumed.

This type of connection is mechanically strong and its electrical resistance is low. As the cooling effect reaches clear down into the bottom of the cavity in the electrode the contact will not soften even when it is heated by the proximity of the arc. The electrode can, therefore, be introduced through the roof of the furnace and be used up to an extremely small rest piece. As no part of the metallic conductor is wider than the electrode it can pass through the same opening which fits closely around the carbon and can be packed in firebrick up to the diameter of the electrode. This method is satisfactory for single electrodes as well as for bundles of them.

The advantages of Keller's connection are:

1. It avoids all intermediary contacts between the current cable and the carbon.

2. It avoids all parts extending beyond the area of the electrode and has no brackets, screwbolts, wedges, etc., which are liable to deteriorate and cause a high maintenance cost.

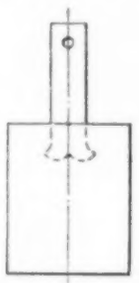


FIG. 38.—ELECTRODE WITH IRON CONNECTION IN TOP

3. It requires no finishing of the electrode surfaces or of the metallic conductor. There is even a certain advantage in leaving the walls of the cavity roughly finished as it improves the contact surfaces and the mechanical strength of the joint.

4. The electrical contact is perfect as the liquid metal fills all the free spaces.

5. The mechanical connection is strong and fool-proof even when the carbon is almost used up.

6. The cost of maintenance is low.

7. The electrode can be used down to below 25 mm. (less than 1 in.) length which dispenses with the cumbersome joining of electrodes.

A practical elastic connection between the electrode and the current leads is used by Keller with the above-mentioned electrodes (German patent 194,897). The successive up and down movement of the electrodes requires flexible leads between the conductor and the carbons. Sometimes an elastic cable of sufficient length serves this purpose. This, however, is subject to considerable wear and tear, takes much space, and is cumbersome for melting furnaces with vertical electrodes, especially so, when they lead the current in and out so that there is the danger of short-circuit.

Keller avoids these difficulties by using thin and very flexible leaf springs of copper, for example 0.5 mm. (20 mils) thick, bundled into two symmetrically arranged bundles and held to-

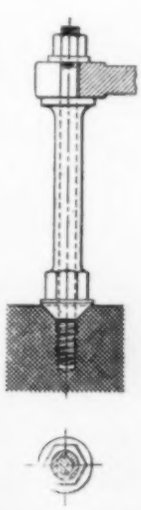


FIG. 39.—SCREW CONNECTION

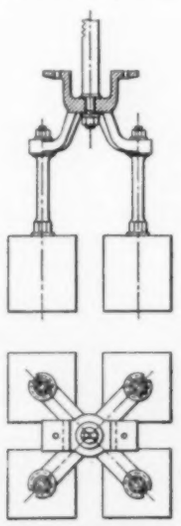


FIG. 40—COMBINATION OF FOUR ELECTRODES

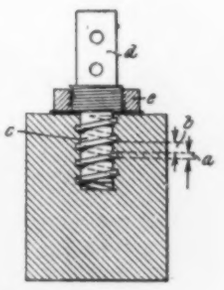


FIG. 41.—CONNECTION OF LESSING

gether at several points by rings. Each side of the electric holder has a guiding rod which causes the leaf springs to be compressed or opened in vertical direction, when the electrodes move down and up. The shape of the leaves is determined by the distances of the rings which make knots when the springs are deflected or stretched.

If the lengths of the single leaf springs are somewhat different from each other the elasticity of each spring is used with best efficiency. There is no danger of a short-circuit and the elastic connection is not exposed to the flames of the furnace. This construction has given excellent service and is used in electric furnaces of various types and employed for a variety of purposes.

Electrode Dimensions and Electrode Bundles

The best cross-section of electrodes is one of the most important questions for the consumer. Above all it is determined by the current density of the electrode. Experience is so far the only guide. A number of important papers on this subject have all been published or reviewed in this journal. No general formula which would be valid for all cases has yet been found for the calculation of this section. In general a good electrical and a poor thermal conductivity of the electrode are desirable to reduce the voltage drop and development of heat by the Joulean effect and so prevent any appreciable loss of heat through the electrodes. Much systematic work remains to be done to find the best conditions for improving the heat balance of furnaces in special cases. In view of the fact that the thermal efficiency of the electric arc furnace is 50 per cent or more, these energy losses through the electrodes are of minor importance. (The reviewer is of different opinion on this point.)

The current density of electrodes depends on the sectional area. It has been proven that round electrodes of from 70 to 100 mm. (2.8 to 4 in.) diameter, as used, for instance, in the Stassano furnace can carry 20 to 25 amp per sq. cm. (129 to 161 amp per sq. in.). (As the reviewer knows, graphite electrodes are used in these furnaces, which accounts for the remarkable difference, with the figures which follow.)

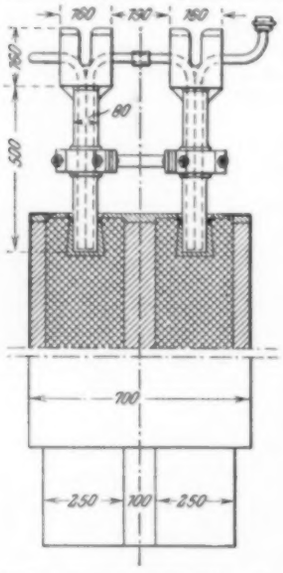


FIG. 42.—CONNECTION OF KELLER

Larger sections are used in the electric steel furnaces of Heroult, Girod, Keller, etc. They cannot carry any such current density. Up to a section of 400 x 400 mm. (16 x 16 in.) 5 amp per sq. cm. (32 amp per sq. in.) are allowed with a temporary overload of 6 to 7.5 amp per sq. cm. (39 to 48 amp per sq. in.).

The large differences in the current-carrying capacity of electrodes of different section are partly due to the thermal and electrical conditions, mentioned above. Most of the commercial electrodes are made in presses. The capacity of the press is limited by its dimensions and design and it seems likely that the smaller sections of electrodes produced under a higher pressure, have a denser structure. From this it would seem that the current-carrying capacity of the electrode is determined by the pressing capacity of the machines.

The area of surface exposed to the cooling effect and the resistance of the electrode play, no doubt, an important part in these considerations.

It is noteworthy, however, how small the differences in the physical constants of small and large electrodes really are. For the identical carbon mixture we find the following values:

Size of Electrode	Specific resistance	Specific gravity
80 mm = 3⅛ in. round	48 to 50 ohms	1.55
300 x 300 mm = 11¾ x 11¾ in. square	65 to 68 ohms	1.50 to 1.52

The consumer of electrodes is anxious to reduce the voltage drop by increasing the section of the electrode. The size of section is limited by the design of the furnace and by the facilities of the electrode manufacturer. Recently much progress has been made so that square electrodes of 550 x 550 mm section (21.6 x 21.6 in.) and round ones of 625 mm (25 in.) diameter can now be bought from the leading factories.

These large sections naturally involve some disadvantages. The current-carrying capacity is reduced, the mechanical strength decreases with increasing section, and the weight of a single electrode reaches a considerable figure. In case of a broken electrode very heavy pieces might have to be removed

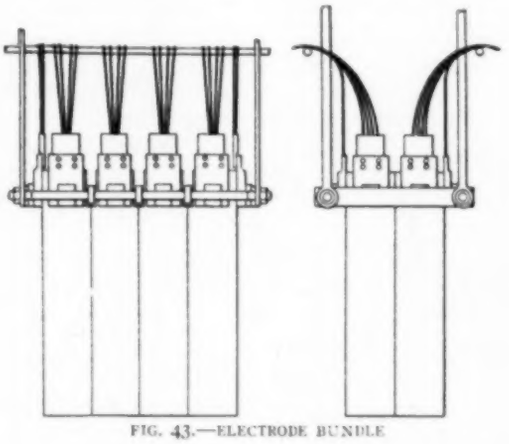


FIG. 43.—ELECTRODE BUNDLE

from a steel bath and an entire heat might be lost by carburization or by cooling off.

The carbide industry, in which large amounts of energy had to be handled at an early date, had previously chosen a different way to overcome the above difficulties. Six or eight or other numbers of smaller electrodes were combined into one package or bundle and lowered by means of cranes into the furnace. The size of the individual electrode is often chosen as 250 x 350 mm (10 x 14 in.). The electrode packages as illustrated in Figs. 24, 25, 42, and 43 leave an unused butt.

The amount of these butts is kept at a minimum by the use of proper water-cooled holders, and whatever remains is used in the carbide furnaces for patching the hearth.

The electric pig-iron furnace in Domnarfvet used three electrodes, each composed of two individual carbons; the over-all section was 660 x 330 mm (26 x 13 in.). In Trollhättan each electrode consists of four pieces of 2 mm (79 in.) length and 330 x 330 mm (13 x 13 in.) section, giving a section of 660 x 660 mm (26 x 26 in.) over all.

The combining of smaller pieces offers the additional advantage that the individual electrode has a higher current-carrying capacity and that considerable losses of energy are avoided.

Attempts have also been made to increase the conductivity of the electrode, for the sake of decreasing the section, by providing a metallic core. Heroult suggested as early as 1892 in U. S. Patent 473,117 (this journal, vol. II, p. 474) to bore holes through the electrodes and fill these with aluminium alloys or silicon alloys.

The "Planiawerke" in Ratibor, Germany, improve the conductivity and mechanical strength by metal fillets introduced before or after the baking of the electrodes (Norwegian Patent 21,366, 1910). The melting or volatilization point of the metal should be below the reaction temperature of the furnace. Measurements show that the resistance of such electrodes "reinforced" by a metallic core can be reduced to at least half of the original with a comparatively small cross section of the core.

The process is particularly intended for use with rather long not continuously fed electrodes. Certain alloys can be introduced into the steel by using same as the core. According to Perkins a tube of the carbon or iron can be filled with lime, iron oxide or other slag-forming materials and thus deliver the very liquid refining slag at the hottest point of the bath.

R. A.

Copper Smelting Operations of the Santa Fé Gold and Copper Mining Co.

By Clarence T. Emrich

The property of the Santa Fé Gold & Copper Mining Company is situated about two miles above the town of San Pedro, in Santa Fé County, New Mexico, at an elevation of about 7600 ft. Here are located the mine and smelter within 800 ft. of each other. A general view of the smelter is given in Fig. 1.

FIG. 1.—COPPER SMELTER OF THE SANTA FÉ GOLD & COPPER MINING COMPANY, SAN PEDRO, N. MEX.

San Pedro is reached via Stanley on the New Mexico Central Railroad and via Los Cerrillos on the main line of the Santa Fé Railroad, a distance of about sixteen miles from the former and eighteen miles from the latter. Stanley is used as the shipping point; first, because of the nearer distance, and, second, because of a less mountainous wagon road.

Operations may be classed under four heads: Power Plant, Mining, Sorting, and Smelting.

Power Plant

The power plant consists of a boiler room, engine room, and machine shop. The boiler room contains three 150-hp return-tubular boilers and the necessary coal bunkers, feed-water pumps and heater. The engine room contains a Franklin cross-compound air compressor, size 16-27-24-14 x 18, capacity of 1100 cu. ft. per minute; one small Ingersoll-Sergeant and one Rand air compressor, both of which are seldom used; one 125-hp Nordberg Corliss driving a Root blower of 85 cu. ft. air per revolution, at an average speed of 98 r.p.m.; one General Electric Company marine generator, 110 volts, 91 amp., 450 r.p.m., used for lighting, and one Harrisburg Standard engine direct-connected to a Crocker-Wheeler generator, 75 kw, 250 volts, 300 amp. at 275 r.p.m. The machine shop contains the necessary lathes, drill presses, shavers, and, in fact, everything necessary to an isolated camp.

Coal is brought by wagons from the company coal mine, which is about sixteen miles north, at a cost of $3.50 per ton for the haul. Water is obtained from the company well and pump house at San Pedro. This plant pumps the water about two miles through an elevation of 1000 ft. to two general supply tanks situated above the smelter site. The water contains a great deal of lime and needs treatment with a soda-ash solution before it is used in the boilers. The corrosive effect is very heavy both in the boilers and furnace, which causes some trouble at times.

Mining is all overhead stoping and drifting. Very little timbering is done; pillars are left in the larger stopes. Hand and machine drills are used.

Sorting the Ore

The ore is a chalcopyrite occurring in a garnet formation and is very hard. The country rock is porphyry, garnet, quartzite and metamorphosed limestone and shale. The ore occurs in three horizons and all are badly faulted. The faults are both normal and reverse. They vary in width from a few inches to a hundred feet with a throw of the same dimensions.

The ore was formerly hoisted in cars on a cage, but this method was changed during the past summer to a 2-ton self-dumping skip, which gives much better results. All ore and part of the waste is delivered by tramming or gravity tramways to a 100-ton bin at the shaft bottom and from there hoisted 180 feet to the surface where it is automatically dumped into the feed bin for the picking-belt. This picking-belt was put in operation in September and has been the means of greatly improving the grade of ore received at the smelter. All ore passes over a grizzly, and the coarser ore to a Blake crusher set to 4 in. It is then elevated to the picking-belt by a belt conveyor, where eight or ten men pick out the waste. The waste is trammed to the dump while the ore drops from the picking belt to a cross conveyor belt which delivers it to the bin at the head of the gravity incline tramway. Two 2-ton skips on a three-rail track deliver the ore to the smelter bins at a cost of about three cents per ton. The smelter bins, three-rail track and shaft buildings are shown in Fig. 2.

Sampling and Analysis of the Ore

The analysis of the ore varies widely from different parts of the mine. A sample is taken by two revolving buckets which catch the ore as it falls from the picking belt to the conveyor belt, and delivers it to the sample bin, also at the head of the gravity tramway. This sample is allowed to accumulate until one of the 150-ton smelter bins is full; then the sample is lowered to the sample house near the bottom of the tramway, where it goes through the usual process of crushing, coning, quartering, etc., to pulp.

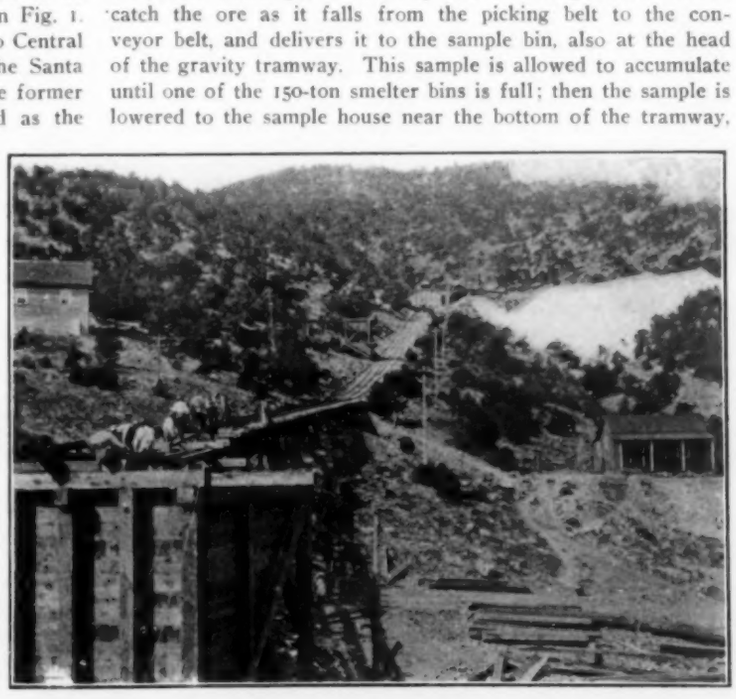


FIG. 2.—LOOKING FROM SMELTER BINS TO MINE SHAFT AND PICKING BELT

Analysis of the ore by treating with acids and fusion varies widely as is seen by the tables below. The treatment with acids gives an erroneous result, due to the garnet which is insoluble and holds up as much as 50 per cent of the SiO_2, Fe

and CaO. The following analyses by acids and fusion were made on the same samples of ore:

Sample No.	With Acids			Fusion		
	SiO_2	Fe	CaO	SiO_2	Fe	CaO
1	65.7	8.8	10.5	36.2	14.0	22.9
2	59.3	13.2	8.8	35.9	20.6	19.6
3	60.5	9.2	10.8	36.8	18.4	21.3
4	60.7	11.7	9.1	43.5	15.1	16.3
5	54.8	6.8	13.8	41.2	10.0	20.1
6	58.1	8.1	11.4	40.8	11.9	18.5
7	65.0	6.9	8.7	34.4	11.5	23.5

Copper Average.....4.2
Sulphur Average.....3.7

The above results are representative of different bins on consecutive days, showing the variety of ore from the mine and the uselessness of the acid analysis so far as the metallurgist is concerned. The past records at this plant show very few analyses by fusion, the acid decomposition being generally used. This, together with the fact that furnace charges were never figured, partly accounts for the frequent "freeze ups" and small tonnage in the past. A comparison of results is given later.

Good Results from Obsolete Type of Furnace

The furnace used here is very much out of date, though good results can be obtained by watching it closely. It is composed of twelve jackets, six of which are steel side and end jackets, and six cast-iron bottom jackets. The side jackets are 9 ft. x 5 ft.; the end jackets are 9 ft. long by 4 ft. 5 in. on the bottom and 6 ft. 5 in. on top. The jackets are straight, with five tuyere holes in each side jacket the same diameter as the tuyeres themselves, which is 6 in. There is no bosh whatever, so when the jackets are in place all the tuyeres point upward to some extent, which helps the fire to the surface of the charge to a greater or less degree. The lower cast-iron jackets are 12 in. high and set on 2-in. bottom plates which are held in place by screw jacks. The intermittent tap is used on the side of the furnace. The two front lower jackets allow the spout to be bolted to the bottom plates. On top of the steel jackets rests an 18-in. fire-brick wall, 2 ft. high to the bottom of 2-in. cast-iron plates or slips which are on an angle of about 45 deg. This also cuts down the furnace shaft, as the furnace is seldom filled above the top of the jackets. This gives a shaft of about 7 ft.

Improved Water-Cooling for Jackets

During previous smelting operations the water always ran hot. There is no doubt about this when the jackets are seen for they are all very badly warped, due to improper cooling, which, by the system of piping that was in, could not be helped. A 4-in. supply pipe reached the furnace on one end from which point it served only three sides of the furnace. On both ends of the furnace (it is tapped on the side) two 2-in. pipes extended from each side of the 4-in. supply pipe to a branch tee from which six 1¼-in. pipes supplied half the furnace. The overflow pipes were closed to within ½ in. with scale. These were all removed and the 4-in. supply pipe extended around the furnace, giving a direct flow to each jacket. There has been no trouble from boiling water since. Overflow pipes empty into a 4-in. pipe at the four corners of the furnace from whence it goes to a general sump tank where all overflow water is collected from the plant. From here it is pumped to a cooling tower, an elevation of about 100 ft. This tower has a receiving tank beneath which furnishes the pressure for the furnace where the water is again returned to the tower. Fresh water is supplied from the high pressure tanks.

The lining for the furnace bottom is composed of a layer of old broken brick to a depth of about 2 in. On this is tamped a mixture of damp flue-dust, coke-dust and adobe to a depth of about 6 in., sloping toward the tap hole where it is 3 in. thick. This bottom gives very good results, is cheap, quickly put in and takes no longer to dry out than a brick bottom. Matte occasionally eats through but is quickly stopped and has not caused any bad results to the furnace plates. The furnace breast is bricked up with two courses of fire-brick placed on edge. This breast is found very convenient at times, when we have no sulphide to hold the matte, except the little sulphur in the ore, and the matte is partly reduced to metallic copper, thus building up the furnace bottom. Then we find ourselves breaking through the brick breast to tap as high as possible under the jackets.

Our settlers are 7½ ft. by 4 ft. by 4 ft. 4 in. outside. These we line with fire-brick on edge in bottom and on the sides. The sides are lined up about 2 ft. with the fire-brick, red brick and bats being used for the remainder. The settlers are tapped on the sides for matte, which drops from a short spout to a truck car on which are five moulds each holding about 150 lb. of matte. The slag runs off in a spout to 5-ton pots. These pots are drawn to the dump by a cable and small hoist which is located near the end of the dump. In summer the hoist is operated by compressed air; in winter by steam.

Results of Former Operations

The method of feeding under former management is seen at a glance from the following data which are taken from the best month's record during 1907:

Charges Ore	Charges Iron Ore	Charges Limestone	Charges Flue Dust	Charges Coke
43@2600#	21@400#	22@400#	7@1400#	50@400#
36@2600	18@400	18@400	11@1500	47@400
42@2600	42@200	42@400	21@1500	63@400
39@2600	5@500	34@500	34@1500	73@350
38@2600	.....	38@500	19@1500	57@350
46@2600	4@500	42@500	23@1500	69@350

This gives a good idea of the method used. If the furnace froze it was cleaned out as quickly as possible and blown in again on the same charge. The records show very small deviations from the above. As no charges were figured at all, the furnace was run by guess, with frequent freeze ups.

Some of the slags and mattes produced during the same period on consecutive days are as follows:

SiO_2	FeO	CaO	Cu Matte
49.1	25.9	18.8	64.6
46.5	25.1	20.3	58.3
47.1	24.2	22.8	63.2
44.0	27.9	19.9	62.7
45.0	19.2	28.2	54.8
42.4	18.8	29.5	55.0
44.9	20.1	27.4	59.8
41.9	25.3	27.3	66.8

The correctness of these slag analyses is not known. More or less metallic copper was made.

Results of Present Operations

Following are some results we have obtained during the present operation under the same conditions with the same fluxes

Charges Ore	Charges Iron Ore	Charges Limestone	Charges Flue Dust	Charges Coke
58@1800#	58@170#	58@180#	58@150#	58@285#
60@1800	60@170	60@180	60@150	60@285
76@1800	76@170	76@180	76@150	76@285
77@1800	77@150	77@200	77@150	77@285
85@1500	85@100	85@350	.....	85@280
78@1650	78@100	78@350	.....	78@280
75@2200	.....	75@125	75@125	75@320
62@2200	.....	.....	62@200	62@320
72@2200	.....	72@125	72@200	72@330

Slags under the same dates give the following results:

SiO_2	FeO	CaO	Cu Matte
40.3	23.6	29.1	....
41.1	23.6	29.2	....
37.5	25.4	28.0	....
38.8	23.2	28.4	70.4
36.5	21.2	31.9	74.4
37.1	20.8	33.5	78.8
39.4	17.3	33.2	62.0
38.0	17.8	35.2	62.9
38.7	17.8	34.4	70.0

Slag Average	Cu	S	SiO_2	FeO	CaO	Al_2O_3	MgO
September	0.60	0.2	37.7	17.0	33.1	9.5	0.7
October	0.69	0.15	38.7	20.6	29.5	8.2	0.7
November	0.53	0.21	37.8	22.2	29.9	6.9	0.7
December	0.53	0.31	37.5	21.3	32.5	6.2	0.9

Note should be taken of the copper slag loss due to small settler and intermittent tapping.

Analysis of Fluxes

	SiO_2	Fe	CaO	S
Iron Oxide	9.5	60.0	....	....
Lime Rock	3.0	1.0	52.0	....
Leadville Sulphide	3.0	40.0	....	50.0

Leadville sulphide has been obtained only during the past few months which allows us to make a 50 per cent. matte and reduce the slag loss. This is quite an item of saving.

Feeding the furnace is all done by hand. The ore cars which carry the ore and fluxes from the individual bins are trammed by hand to the charge floor where they are dumped on plates, one on each side of the furnace. From here two men shovel it into the furnace. Before we obtained Leadville sulphide two charges were fed at a time, one on each side of the furnace. We tried this method at first with the sulphide, by mixing the sulphide to give about a 50 per cent matte. We found this gave us only from 18 per cent to 20 per cent of the sulphur, for our charge in the furnace is usually hot on top. Now the charge is allowed to go down about 2 ft. when enough sulphide for four charges is put in all at once and covered with four charges of ore and flux as quickly as possible. This method gives us about 30 per cent sulphur. Our flue-dust is drawn from the dust chamber, mixed with about 20 per cent water and fed before the ore. This is weighed to give 200 lb. net and is very satisfactory. Our blast pressure averages 14 oz. of mercury.

Our matte is weighed at the end of each shift and then piled away to be shipped.

Cost of Labor and Transportation

Shifts in the mine, picking belt and surface gang are 10 hours while those in the smelter and engine room are 12 hours. Mexican labor is used entirely.

Smelter		Mine and Other	
Feeders	$3.30	Machine men	$3.00
Tappers	3.50	Machine helpers	2.50
Helpers	2.70	Muckers	1.75
Spout men	2.25	Blacksmith	4.00
All others	2.10	All general Labor	1.75

All hauling by wagon from Stanley costs $4.00 per ton. We now have a Rumely oil traction engine drawing two 10-ton trucks and an American-La France Motor Truck. These have reduced the cost of hauling to $1.50 per ton.

San Pedro, N. M.

The First Electric Steel Casting Plant on the Pacific Coast.—The Washington Iron Works, of Seattle, Wash., manufacturers of mill, mining, and marine machinery, are installing a three-ton Girod electric furnace in their new foundry, together with complete steel foundry equipment for the manufacture of high-grade castings. This company makes a specialty of logging and hoisting engines. This will be the first electric steel casting plant on the Pacific Coast.

The Colorado School of Mines senior class is taking the annual trip of mining and metallurgical inspection, having left Denver on April 21, and planning to return on May 21, two days prior to commencement exercises. The itinerary will include prominent mining and metallurgical districts in Colorado, Utah and Montana. Seven members of the faculty and seventy students comprise the party, which is traveling in a special train.

Note on Cold-Junction Corrections for Thermocouples

By Paul D. Foote

Ordinarily, in the laboratory use of thermocouples the cold junction is kept at a standard reference temperature such as the melting point of ice, while the hot junction is placed within the furnace or substance the temperature of which is desired. However, for technical purposes and general commercial use, it is not always convenient to have an ice box at hand. For this reason it is desirable to work with the cold junction at the temperature of the room. This necessitates a knowledge of the corrections to apply to the indicator readings, provided that the standardization of the pyrometer were carried out with the cold junction at some temperature other than that used in the technical works. The importance of these corrections is realized when one considers the large range of the cold-junction temperature, which in practice frequently varies from 10 to 100° C.

In order to obtain the temperature corresponding to any

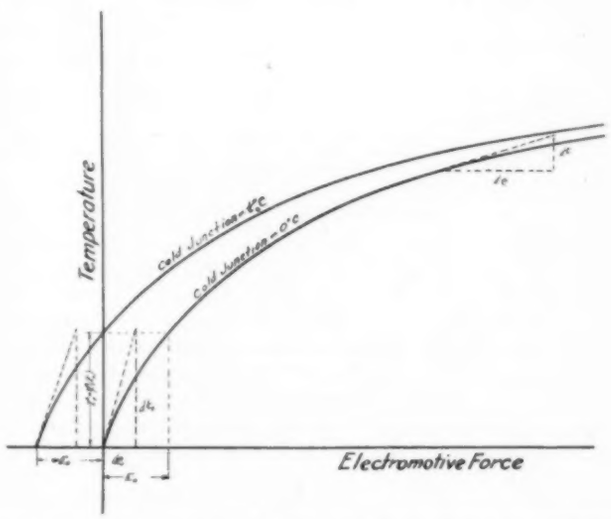


FIG. 1.—ILLUSTRATING THE SHIFT OF THERMOCOUPLE CURVE WITH A CHANGE OF THE COLD-JUNCTION TEMPERATURE

value of the emf observed when the cold junction is at a temperature of t_0° C. from the relation $e = f(t)$ computed on the basis that the cold junction is at 0° C., it is only necessary to add to the observed emf the value of the emf developed when the cold junction is at 0° C. and the hot junction is t_0° C., a number which is independent of the temperature of the furnace. However, many pyrometer galvanometers are calibrated to read temperature directly and have no scale of emf recorded. One must then express the correction in terms of degrees, and this quantity for any given value of the cold junction will depend, of course, upon the temperature of the hot junction, for the reason that in general the relation between temperature and emf is not linear. A table, accordingly, might be prepared stating the corrections to be applied to the temperature observations for all values of the hot-junction temperature and all variations in the temperature of the cold junction.

The usual method of obtaining the cold-junction correction consists in multiplying the value of the cold-junction temperature by certain empirical factors. R. Vogel[1] computed these factors for a Heraeus (Pt, 90Pt-10Rh) couple having a cold junction of 50° C. Offerhaus and Fischer[2] have calculated the factors for several types of couples.

This method of correction for cold-junction temperatures may be derived in the following manner:

---

[1] R. Vogel, ZS f. Anorg. Chem., 1905, 45.

[2] Cornelis Offerhaus and E. H. Fischer, Electrochem. and Metal. Ind., Sept., 1908, pp. 362-364.

Derivation of the Slope Correction.—Let e and t be the observed emf and corresponding temperature when the cold junction = 0° C.

e_1 and t_1 = the observed emf and temperature when the cold junction = t_0° C.

For any thermocouple

$$e = f(t) \qquad (1)$$

then for any value e_1

$$e_1 = f(t_1) \qquad (2)$$

But $e = e_1 + e_0$ where $e_0 = f(t_0)$ = emf developed when the hot junction = t_0° and the cold junction = 0° C.

Substituting in (1)

$$e_1 + e_0 = f(t) \qquad (3)$$

From (3)

$$t = \phi(e_1 + e_0)$$

From (2)

$$t_1 = \phi(e_1)$$

Denote by p the correction to add to the observed temperature when this value is read from the plot of a couple calibrated with its cold junction = 0° C.

$$p = t - t_1 = \phi(e_1 + e_0) - \phi(e_1)$$

$$= \phi(e_1) + e_0\phi'(e_1) + \frac{e_0^2}{2}\phi''(e_1) + \ldots - \phi(e_1)$$

$= e_0\phi'(e_1)$ provided e_0 and t_0 are small in comparison with e_1 and t_1.

$$\text{hence } p = \frac{e_0}{\phi(e_0)}\phi'(e_1)\phi(e_0) = \frac{e_0}{\phi(e_0)}\frac{dt_1}{de_1}t_0$$

$$= \frac{de_0}{dt_0}\cdot\frac{dt_1}{de_1}t_0 = \frac{\left(\frac{de}{dt}\right)_0}{\left(\frac{de}{dt}\right)_1}t_0 \text{ approximately.}$$

This equation, therefore, states that in order to obtain the true temperature (t) it is necessary to add to the observed temperature (t_1) the quantity obtained by multiplying the temperature of the cold junction (t_0) by the ratio of the slopes of the calibration curve at the origin and at the temperature (t_1). The derivative $\left(\frac{de}{dt}\right)_0$ is but approximately equal to the quantity $\frac{e_0}{\phi(e_0)}$ and becomes less so the farther t_0 departs from zero. As seen from Fig. 1, $\frac{e_0}{\phi(e_0)}$ is more exactly the mean slope of the calibration curve from 0 to t_0° C. Using this value the single term slope correction becomes:

$$p = \frac{\left(\frac{de}{dt}\right)_{0-t_0}}{\left(\frac{de}{dt}\right)_1}\cdot t_0.$$

The mean slope of 0 to t_0 may be determined accurately enough by assuming some value of t_0 in the neighborhood of the actual value of the cold-junction temperature, such as 30° C., and computing the mean slope from 0° to this point, *i.e.*, the value of the emf observed when the cold junction is at 0° and the hot junction 30° divided by 30. This form of the cold-junction correction requires but a single measurement of the emf at room temperature, whereas the usual form of correction practically necessitates a knowledge of the curve at several points in order to evaluate the slope at 0° C. The three forms of cold-junction temperature correction may be summarized thus:

Form I $$p = e_0\phi'(e_1) + \frac{e_0^2}{2}\phi''(e_1) + \ldots + \frac{e_0^n}{n}\phi^n(e_1) + \ldots$$

Form II $$p = \frac{\left(\frac{de}{dt}\right)_0}{\left(\frac{de}{dt}\right)_1}t_0$$

Form III $$p = \frac{\left(\frac{de}{dt}\right)_{0-30}}{\left(\frac{de}{dt}\right)_1}t_0$$

Form I is the correct expression of the cold-junction correction.

Form II is the approximation in general use.

Form III is the approximation which should be given preference over Form II.

Magnitude of the Cold-Junction Correction.—Fig. 2 illustrates the magnitude of the true cold-junction corrections for P_3 a (Pt, 90 Pt — 10 Rh) Heraeus couple having for its temperature-emf relation the equations:

$$e \times 10^4 = 56.04t + 0.05434t^2 \quad 0 \text{ to } 100° \text{ C.}$$

and

$$e \times 10^4 = -2820 + 80.71t + 0.01694t^2 \quad 300 \text{ to } 1500° \text{ C.,}$$

where e is expressed in millivolts. These curves represent the *true* correction, Form I, for four observed hot-junction temperatures, and with the cold-junction temperature varying from 0 to 100° C. It is seen that the amount to be added to the observed temperature may reach a value as high as 60 or 65 Centigrade degrees.

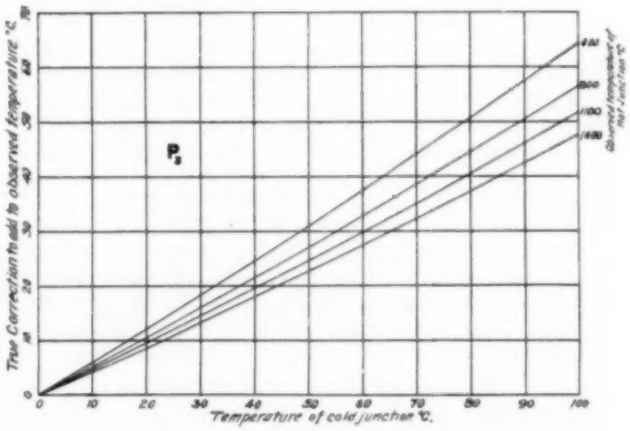


FIG. 2.—TRUE CORRECTION VS. COLD-JUNCTION TEMPERATURE

Errors in the Slope Corrections.—How closely Forms II and III express the true corrections for the cold-junction temperature depends upon the form of the function $e = f(t)$. Inasmuch as the series in Form I is frequently only slowly convergent a more convenient method than evaluating each term was used for determining the errors in the approximation corrections.

Several of the Bureau of Standards' thermocouples were calibrated (cold junction = 0° C.) from 0 to 1500° C. Assuming the temperature of the hot junction so regulated that any definite value of the observed emf developed by the couple remains constant whatever the temperature of the cold junction, the emf's for a cold junction 0° C. were obtained by adding to the observed value the emf readings between 0 and 100° C. The temperatures corresponding to these new emf's were computed and from them was subtracted the temperature corresponding to the observed emf. The differences are the true corrections to be applied to the observed temperature for a series of cold-junction temperatures. This operation was repeated for several different observed values of the emf. The slope corrections were then computed for the same points.

Fig. 3 presents the errors met with in the application of the slope corrections, Forms II and III, to P_3 (Pt, 90 Pt — 10 Rh). The upper group of curves shows the amount to be added to the slope correction, Form II, to obtain the true correction. The largest error is 5°, with the hot junction at an observed temperature of 400° and the cold junction 100° C. The lower group of curves represents the corrections to apply when the slope correction is computed on the basis of the mean slope from 0 to 30° instead of 0° C., Form III. The errors are all

somewhat smaller in this case, the maximum being 3°, and hence, in general, the correction according to Form III is to be preferred.

Similar curves were obtained for P_2, a Johnson and Matthey (Pt, 90 Pt — 10 Rh) couple having the equations:

$e \times 10^4 = 63.86t + 0.07343t^2$ 0 to 100° C.

$e \times 10^4 = -4934 + 99.06t + 0.01594t^2$ 300 to 1500° C.

Fig. 4 illustrates the errors found in the use of the slope

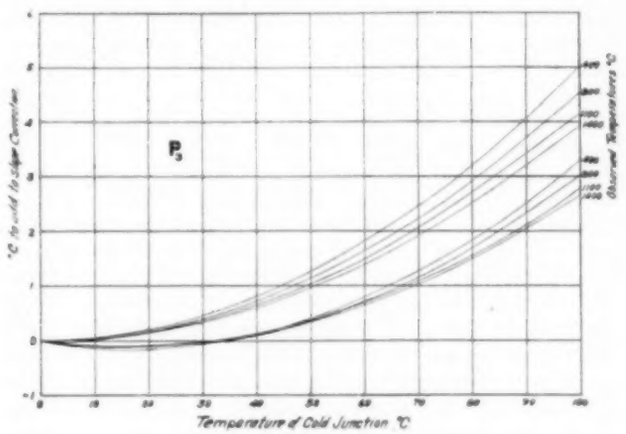


FIG. 3.—ERROR IN SLOPE CORRECTION

corrections with W_2. This couple, which was obtained from Pellin, and supposed to have the composition (Pt, 90 Pt — 10 Ir), had a temperature-emf relation expressed by the equations:

$e \times 10^4 = 84.76t + 0.1603t^2$ 0 to 100° C.

$e \times 10^4 = -6260 + 130.2t + 0.03381t^2$ 300 to 1500° C.

The maximum error found for Form II is about 10° with the hot junction at an apparent temperature of 400° and the cold junction 100° C. The lower group of curves is computed on the basis of the preferred form of the slope correction, Form III. The maximum error in this case is 6°.

For a copper-constantan couple of Adams and Johnston[2] having the equation:

$$e \text{ (microvolts)} = 38.105t + 0.04442t^2 - 0.00002856t^3$$

applicable over a range 0 to 350° C., the ordinary slope correction, Form II, is an error from 0.1° to 0.5° when the cold junction varies from 0 to 20°. With a cold junction of 20 to 50° this slope correction is too small by amounts running from 0.5 to 2°. Form III applied to this couple shows corrections somewhat nearer those given by the true correction term, Form I.

Applicability of Slope Corrections.—If the couples examined are typical of all (Pt, 90 Pt — 10 Rh), (Pt, 90 Pt — 10 Ir), and copper-constantan couples, one may conclude that for values of the cold junction from 0 to 50° C. in the case of the platinum-platinum alloy couples, and from 0 to 20° C. in the case of the copper-constantan couple the slope correction, Form III, is fully applicable, and is not in error by amounts greater than the precision attainable with the ordinary pyrometric galvanometer. For all technical work it is sufficient to add to the galvanometer temperature reading the number obtained by multiplying the ratio of the mean slope from 0 to t_0 and the slope at the observed temperature (t_1) by the temperature (t_0) of the cold junction.

The ratio of the slopes are given in the form of numerical factors for thermocouples tested at the Bureau of Standards, and to all technical purposes are alike for similar couples. Their determination requires only a rough temperature-emf calibration made independently of the pyrometer indicator. Instead of a table of figures, the observer need remember but two or three numbers applicable over all ranges of the cold-junction temperature. Thus in the use of P_2 with any type of galvanometer indicator it is sufficient in ordinary pyrometric work to correct for the cold-junction temperature, t_0° C., by adding to the observed temperature, t_1° C., the amount $0.6t_0$ from 400 to 700° C. and $0.5t_0$ from 700 to 1400° C., where t_0 is less than 50. If closer accuracy is desired, a number of slope values computed to another significant figure, as given in Table I, second column, or preferably the third column, must be used, and the corresponding corrections shown in Fig. 3 applied. For the highest attainable accuracy a potentiometer is required, and the emf corresponding to the temperature of the cold junction is added to the emf reading of the couple.

TABLE I—TEMPERATURE CENTIGRADE VS. COLD JUNCTION FACTOR. P_2 (Pt, 90 Pt—10 Rh)

Observed Temperature °C.	$\left(\frac{de}{dt}\right)_0 \div \left(\frac{de}{dt}\right)_1$	$\left(\frac{de}{dt}\right)_{0\text{-}30} \div \left(\frac{de}{dt}\right)_1$	$\left(\frac{de}{dt}\right)_{30\text{-}60} \div \left(\frac{de}{dt}\right)_2$
400	0.59	0.61	0.63
500	.57	.59	.61
600	.55	.57	.59
700	.53	.55	.57
800	.52	.54	.56
900	.50	.52	.54
1000	.49	.50	.52
1100	.48	.49	.51
1200	.46	.47	.49
1300	.45	.46	.48
1400	.44	.45	.47

The second column shows the factor by which the value of the cold junction temperature must be multiplied when using the old type slope correction, Form II. The third column contains the factors computed from the preferred form of the slope correction, Form III. The fourth column shows the factors when the couple is calibrated with the cold junction at 30° C. and used with a cold-junction temperature not far from 40° C.

Slope Correction When the Couple Is Calibrated with the Cold Junction at a Temperature Other Than 0° C.—Many thermocouple pyrometers are so constructed that it is impracticable to calibrate them with a cold junction at 0° C. Suppose the standardization were carried out with a cold junction of ${}_1t_0 = 30$° C. and it is desired to use the couple near a furnace where the room temperature is ${}_2t_0 = 40$° C. Proceeding by a method similar to that shown in the derivation of the ordinary slope correction we now obtain the correction term:

$$p = \frac{e_0}{{}_2t_0 - {}_1t_0}\,\phi'(e_2)\,({}_2t_0 - {}_1t_0)$$

where $\phi'(e_2)$ is the slope at the point corresponding to the

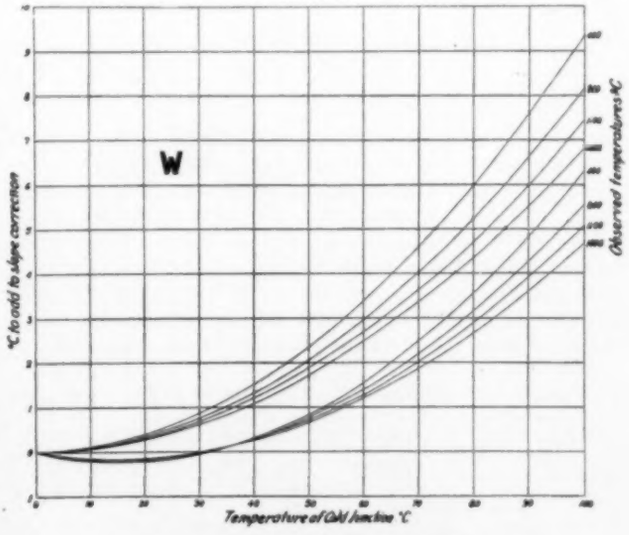


FIG. 4.—ERROR IN SLOPE CORRECTION

observed emf, and e_0 = the emf developed when the cold junction is at the temperature ${}_1t_0$ and the hot junction ${}_2t_0$, or:

$$p = \frac{\left(\frac{de}{dt}\right)_{30\text{-}60}}{\left(\frac{de}{dt}\right)_2}\,({}_2t_0 - 30)$$

where ${}_2t_0$ is not far from 40, t_2 being the observed temperature, corresponding to e_2.

[2] L. H. Adams and J. Johnston Am. Jour. Sc., Vol. 33, June, 1912, p. 534.

This equation, therefore, states that in order to obtain the true temperature, t, it is necessary to add to the observed temperature, t_2, the quantity obtained by multiplying the difference in the temperature of the cold junction used in the standardization, ${}_1t_0 = 30$, and during any observation, ${}_2t_0 = 40$, by the ratio of the mean slope of the calibration curve from 30 to 40° and the slope at the observed temperature. The mean slope from 30 to 40° is obtained by dividing the emf observed when the cold junction is 30° and the hot junction is 40° by 10. The factors for P_3 used in this manner are given in Table I, column four.

Reduction to Fahrenheit Scale.—All the temperatures referred to above are given in degrees Centigrade. The conversion to the Fahrenheit scale occasions no difficulty. When the couple is originally calibrated with the cold junction at the temperature of melting ice, 32° Fahr., and used with the cold junction at the temperature, t_0° Fahr., the actual temperature, t, of the hot junction is obtained by adding to the observed temperature, t_2, the value of the product $(t_0 - 32)K$, instead of $t \cdot K$, where K is the correction factor at the particular observed hot-junction temperature. If the couple is calibrated with the cold-junction temperature of ${}_1t_0$° Fahr. and used with the cold junction at a temperature of ${}_2t_0$° Fahr., the correction term to be added to the observed temperature, t_2, has the same form as before,

$$p = ({}_2t_0 - {}_1t_0)K'$$

where K' is the factor computed from the mean slope between ${}_1t_0$ and ${}_2t_0$, and the slope at the observed temperature. The values of the ordinates for the curves in Figs. 2, 3, and 4 should be increased by the factor 9/5, while the abscissae are directly converted to the Fahrenheit scale. As an example, in the case of Fig. 4, the ordinates will lie between the 0 and 18, the abscissae between 32 and 212° Fahr., and the observed temperatures of the hot junction become 752, 1472, 2012, and 2552° Fahr. In Table II are given the correction factors for P_3 (Pt, 90 Pt — 10 Rh) for a series of observed temperatures ° Fahr. These follow directly from Table I. The second column shows the factors computed on the basis of the old slope correction, Form II. The third column contains the factors computed from the preferred slope correction, Form III. In the fourth column are given the correction factors when the couple is calibrated with a cold-junction temperature of 86° Fahr. and used with the cold junction not far from 104° Fahr.

TABLE II.—TEMPERATURE FAHRENHEIT VS. COLD JUNCTION FACTOR
P_3 (Pt, 90 Pt—10 Rh)

Observed Temperature °F.	$\left(\frac{de}{dt}\right)_{32} \div \left(\frac{de}{dt}\right)_1$	$\left(\frac{de}{dt}\right)_{27\text{-}38} \div \left(\frac{de}{dt}\right)_1 = K$	$\left(\frac{de}{dt}\right)_{86\text{-}104} \div \left(\frac{de}{dt}\right)_2 = K'$
800	0.59	0.61	0.63
1000	.56	.58	.60
1200	.54	.56	.58
1400	.53	.54	.56
1600	.51	.52	.54
1800	.49	.51	.53
2000	.48	.49	.51
2200	.46	.47	.49
2400	.44	.45	.48
2600	.43	.44	.46

TABLE III.—CORRECTION TO THERMOCOUPLE SCALE

Thermocouple Scale °C.	Correction to Add Degrees Centigrade	Thermocouple Scale °F.	Correction to Add Degrees Fahrenheit
300–1200	0	600–2200	0
1300	+2	2400	+5
1400	+6	2600	+14
1500	+14	2800	+35

Conversion of the Thermoelectric Scale to the Standard Temperature Scale.—When the ordinary parabolic equation $e = a + bt + ct^2$ is applied to a (Pt, 90 Pt — 10 Rh) or (Pt, 90 Pt — 10 Ir) thermocouple standardized at three temperatures, the melts of zinc, antimony, and copper, the curve extrapolated to 1500° C. differs somewhat from the temperature shown by the gas thermometer. This is treated in full in "*The Measurement of High Temperatures*," *pp.* 112-116 *loc cit*, but may be briefly summarized in the following table, which holds approximately for the usual type of platinum, platinum-iridium, and platinum-rhodium couples.

The above discussion of couples P_3, P_4 and W_7 is on the basis of the thermoelectric scale. Hence temperatures higher than 1200° C. or 2200° Fahr. should be further corrected in accordance with Table III. The order of applying the cold junction correction and the above correction is of little importance since both are small. Couples calibrated by the Bureau of Standards are corrected as shown in Table III so that the temperatures indicated by them accord with the established gas thermometer scale.

Devices for the Elimination of the Cold-Junction Correction.—Various methods have been proposed for the elimination of the cold-junction corrections. If a coil of copper wire were shunted across the terminals of the thermocouple in the head of the instrument, an increase in the temperature of the cold junction, ordinarily producing a decrease in the observed emf, would increase the resistance of the shunt and thus tend to compensate for the thermoelectric effect. However, for exact compensation at all temperature ranges, a coil of wire would be required of which the resistance is a function not only of its own temperature, but also of the hot-junction temperature. This, of course, is impossible to realize in practice, but the method might be applied as a partial correction.

Bristol[4] base metal couples are provided with extension wires which permit the location of the cold junction in a constant temperature room some distance from the furnace. Bristol has also devised an automatic compensator consisting of a bulb of mercury into which a loop of platinum wire dips. This is inserted in the circuit near the head of the couple so that the variations in the cold-junction temperature cause the mercury to expand or contract and short-circuit different lengths of the wire loop, thus altering the resistance with a result somewhat similar to that obtained by the use of a shunt coil.

Hartmann and Braun have the cold-junction head jacketed in order that a stream of water may be used to keep the head at an uniform temperature.

The Crompton Company use a multiple scale on their galvanometers so constructed that the pointer reads directly the temperature of the furnace, each scale corresponding to some definite value of the cold-junction temperature.

Several instrument makers have tried interposing a supplementary thermocouple circuit of inexpensive material, the hot junction being located at the cold end of the main thermocouple and the cold junction at the galvanometer, some distance away.

Possibly the most simple compensating device is that employed by Siemens & Halske, and one or two other firms. Here the galvanometer indicator has a large zero adjustment so constructed that the pointer may be set, on open circuit, at the temperature corresponding to that of the cold junction, the graduations having been previously empirically determined for the given thermocouple.

All of these methods possess certain advantages, but many of them are open to the objection that they are cumbersome and frequently liable to introduce new errors. Attention might well be given to the more careful construction of the indicating instruments. Many galvanometers have a temperature coefficient so large that small variations in the room temperature affect the readings to a marked degree. This may give rise to errors as large as those commonly found for the cold-junction temperature.

It is, moreover, needless to mention that the ordinary indicator should not be used in close proximity to other magnetic instruments or to iron unless originally calibrated in that position. A simple trial will readily convince one that this precaution is necessary.

[4] The following and other methods of cold-junction compensation are discussed in "The Measurement of High Temperatures," Burgess and Le Chatelier, p. 156, 3rd Ed., 1912, Wiley, N. Y.

When due care is exercised to locate the galvanometer in such a position that its magnetic field is not disturbed by outside influences and where its temperature is reasonably constant, to occasionally recheck the thermocouple calibration, and to properly correct for the cold-junction temperatures, the simple thermocouple without any compensating devices whatever will prove very satisfactory. Acknowledgment is due Mr. I. N. Kellberg for computing and drawing the curves shown, and to Dr. G. K. Burgess for a number of suggestions.

Bureau of Standards, Washington, D. C.

Heat Transmission and Entrainment in Vacuum Evaporators

An Account of an Elaborate Series of Tests, by Prof. E. W. Kerr, in which the Effect of Various Elements on Heat Transmission and Entrainment was Analyzed.

A very elaborate series of tests of a vacuum evaporator with especial regard to heat transmission and, secondly, to entrainment has been carried out under the direction of Professor **E. W. Kerr** at the Agricultural Experiment Station of the Louisiana State University and A. & M. College, at Baton Rouge, La. Professor Kerr was assisted in this experiment by Mr. **A. J. Isacks.** Assistance was also given in the experiments by Messrs. H. A. Nadler, E. M. Copp, J. F. Gunther, A. Guell

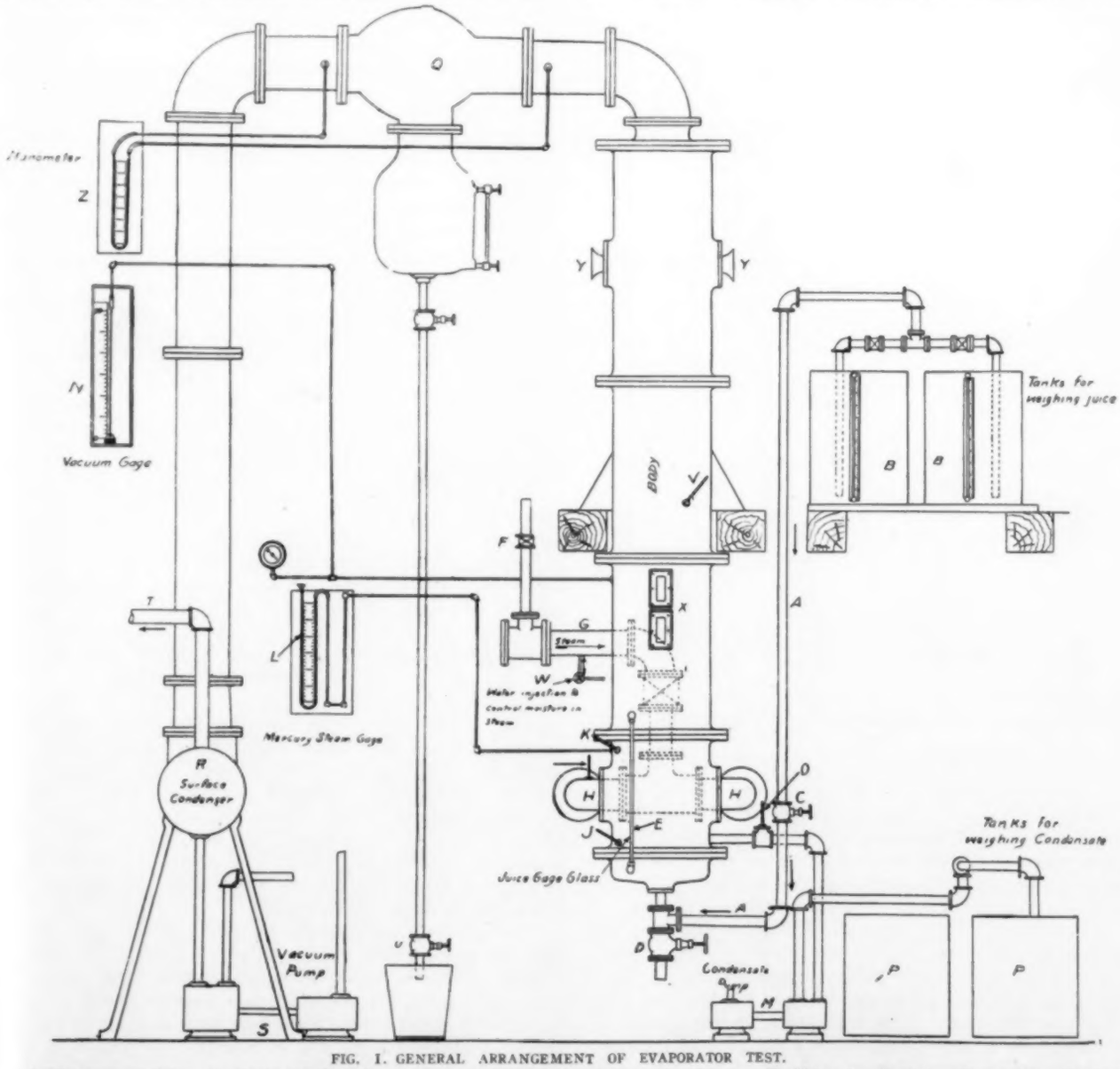


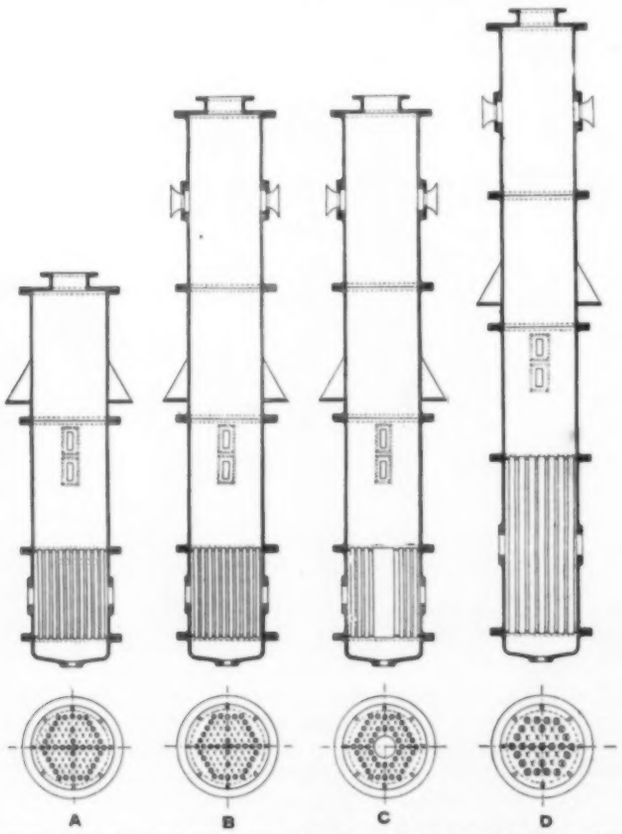
FIG. 1. GENERAL ARRANGEMENT OF EVAPORATOR TEST.

A—Entrance of Juice. B—Tanks for Weighing Juice. C—Valve for Regulating Juice Supply. D—Valve for Emptying Evaporator. E—Gage Glass for Observing Level of Juice. The Steam Enters Through Valve F, Expands Into Pipe G and Divides and Enters Through Pipes H Into the Calandria. I J K—Thermometers, L—Manometer, N—Vacuum Gage. M—Wet Vacuum Pump for Removing Steam Condensed in Calandria. P—Barrels on Platform Scales for Measuring Condensate. O—Catchall or Separator for Catching Any Juice Carried Over by Entrainment. R—Surface Condenser. S—Wet Vacuum Pump. T—Connection to Dry Vacuum Pump (Not Shown). X and Y—Side Glasses for Observing Inside of Evaporator.

and W. P. Denson. The complete account of the experiments is given in Louisiana Bulletin, No. 138, of the Agricultural Experiment Station, Baton Rouge, La. In the following article we give a summary of the experiments and results.

Since a triple or double effect is more complicated and more difficult of control in operation than a single effect it was decided to use a single effect evaporator for the experiments, but to have it arranged so that both the pressure of the steam supply and the vacuum in the vapor space could be thoroughly controlled and made any desired and predetermined amount. In this way, the conditions as regards steam pressure, vacuum, density of juice, etc., of either body of a multiple effect could be reproduced.

Fig. 1 shows the arrangement of the test which, with the description in the caption, will be easily understood. Originally it was the intention to supply a pump with which to remove the syrup from the evaporator in the manner usually employed in sugar factories. It was finally decided, however, not to remove the syrup during operation, but to supply water instead of juice to the evaporator at a rate equal to that at which water is removed by evaporation. In this manner the density of the juice in the charge before the operation started could be kept constant without the use of a syrup pump.



FIGS. 2 TO 5.—THE FOUR EVAPORATOR DESIGNS EMPLOYED IN THE TESTS

The condensing of the vapors was effected by means of the surface condenser R containing a total of 150 square feet of cooling surface. Cooling water was supplied to the condenser from the mains of the Baton Rouge Water Works. The condensed vapors were removed from the condenser by means of the wet vacuum pump S. In most of the tests this pump was sufficient for obtaining the vacuum necessary though where more than about 23 in. was required it was necessary to use a rotative drive vacuum pump, not shown in the figure, in addition to the wet pump. With both pumps it was possible to carry a vacuum of 27 in. The suction pump of the dry vacuum was connected to the condenser as shown at T. The 1¼-in. pipe attached to the bottom of the catchall Q was used for intercepted juice and condensation. By properly manipulating the valves U this could be done while the evaporator was operating and under vacuum. The temperature in the vapor space of the evaporator was observed by means of the thermometer V inserted in a deep thermometer well. All other details will be understood from the descriptions in the caption below Fig. 1.

Four different arrangements of the evaporator itself were used in the tests as shown in Figs. 2 to 5. Fig 2 shows the arrangement A of the evaporator body as first used containing 80 tubes, 1⅜ in. in diameter and 24 in. long. The tubes were of copper and 18 gage B. W. G. The inside diameter of the body was 20 in. The height of the vapor space, upper tube plate to top, was 6 ft.

After the first experiments had been made it was decided that the height of the vapor space was insufficient and the design was changed to B as shown in Fig. 3, in which the height of the vapor space is 10 ft. Bell eye-glasses were added. The height of the vapor space is the same in the designs Fig. 4 and 5 as in Fig. 3. The arrangement C of Fig. 4 shows an evaporator body C with "down take." There are 66 copper tubes, 1⅜ in. in diameter, 24 in. long, 18 B. W. G. The down take of 6 in. in diameter is made of copper 13 B. W. G. copper tube plates ¼ in thick, height of vapor space 10 ft.

The arrangement D shown in Fig. 5 shows an evaporator body without down take. There are 39 copper plates, 2 in. x 48 in., 18 B. W. G. Copper tube plates ¼ in. thick, height of vapor space 10 ft.

The methods employed in making the experiments are described in the bulletin and extensive tables are given comprising the total results of all the tests.

In this article the "coefficient of heat transmission" is defined as the "B.t.u. transmitted per square foot of heating surface per hour for each degree difference of temperature of the two sides of the heating surface." This temperature difference is called the "temperature fall."

Effect of Varying the Head of Juice on Evaporation

Operating an evaporator with a high head of juice is detrimental to heat transmission, and therefore to capacity, because it reduces the temperature fall. This is due to the fact that the average temperature of the boiling juice is increased because of the increased pressure due to the weight of the liquid.

The theoretical average boiling pressures and temperatures as affected by hydrostatic head may be calculated, provided the head of the juice H and the density of the juice are known. Let us assume H to be 48 in. and the density of the juice to be 0.957, then a particle of water at the surface will be converted into steam under a pressure of the vapor space above the liquid, while a particle at the lower end of the tubes will be formed into vapor under the same pressure plus that due to the weight of the column of liquor above it. The average pressure of boiling will, therefore, be that in the vapor space plus the pressure due to half the column of liquor—that is, 24 in. The weight of a cubic inch of liquor with density 0.957 is 0.035 lbs. and the pressure per sq. in. due to 24 in. head is $0.035 \times 24 = 0.83$ lb. per sq. in., or $0.83 \div 0.49 = 1.69$ in. mercury. Hence the average vapor pressure of the juice will be 1.69 in. of mercury higher than the pressure in the vapor space above the liquid, and the effective boiling temperature will be correspondingly increased, and consequently the effective temperature difference between the outside and inside in the evaporator will be reduced If a calculation of this kind is carried out for multiple-effect evaporators it is found that this loss is greatest in the last effect where the pressure is lower than in the preceding vessels.

To determine experimentally the effect of the static pressure due to the weight of juice in reducing the effective temperature difference which causes evaporation, three series of tests were made. The results of these tests are shown in Fig. 6. Curve A refers to tests made with the evaporator of Fig. 2, the steam pressure being 3.75 in. mercury, the vacuum in the vapor space 3 in. Curve B refers to tests made with the evaporator of Fig. 5, the steam pressure being atmospheric and the vacuum in the vapor space being 8 in.

Curve C refers to tests made with the same evaporator (Fig. 5), but with a vacuum of 21 in. in the same calandria and a vacuum of 25 in. in the vapor space.

All three of these series were performed with water instead of juice for the reason that it would have been practically impossible to keep the density of the juice constant, with varying depths, and this would have introduced a second variable which would have made it impossible to isolate the effect of "head."

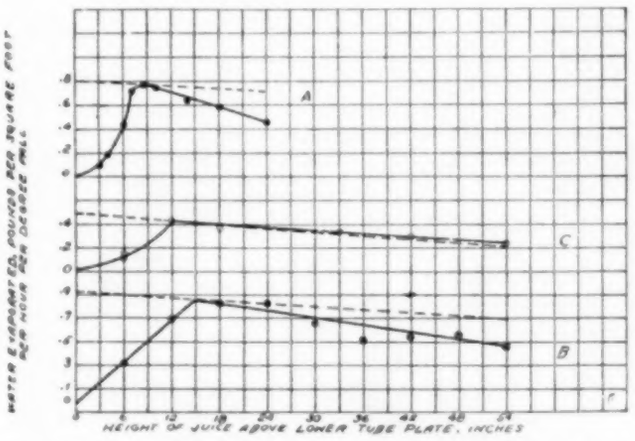


FIG. 6.—CURVES SHOWING THE INFLUENCE OF "HEIGHT OF BOILING" UPON HEAT TRANSMISSION. WATER BOILED IN EACH SERIES.

The broken straight lines in each of the three curves, Fig. 6, show the theoretical variation of heat transmission with change of head, calculated as outlined above, this line being drawn through the highest point of the experimental curve in each case. The ordinates in these curves represent pounds of water per square foot of heating surface per hour, per degree fall.

In series A (see curve A) it will be noted that the maximum capacity was attained with about 77 in. head—that is, with the surface of the liquid in the neighborhood of one-third the length of the tubes above the lower tube plate; in fact, the head for maximum capacity was better defined in this series than in the other two, for the reason that a greater number of tests were made with heads near that for maximum capacity. However, it is clear that the highest point in curves B and C are both with heads between 12 in. and 18 in. and thus showing that the maximum capacity was obtained with heads one-quarter to one-third the height of the tubes.

The curves show a very rapid decrease in capacity as the head is reduced below that giving the maximum capacity. This is due to the fact that with the low heads portions of the heating surface at the tops of the tubes are not effective, being uncovered by liquid. The unsubmerged portion of the heating surface will transmit only a small amount of heat from the steam on the one side to vapor on the other side, which will superheat the latter.

It will be noted that all three curves are straight lines for heads greater than that for maximum capacity, and are thus similar to the theoretical in this respect. The fact that curves A and B are lower than the theoretical indicates the actual loss due to high boiling to be greater than the theoretical. In A the maximum coefficient of heat transmission was 976 with a head of 7 in., whereas the minimum was 490 with a head of 24 in.—that is, a loss of 49.8 per cent. by increasing the head from 7 in. to 24 in. The actual coefficient was also 27.1 per cent. less than the theoretical at 24 in. head. Similarly, the lowest coefficient—that is, with 54 in. head—in B was 44.7 per cent. below the maximum and 31.8 per cent. below the theoretical lowest.

In C the minimum, at 54 in. head, was 42 per cent. below the maximum. The C series differed from the other two, however, in that the theoretical curve almost coincides with the actual. The reason for this is not apparent. In this series the average evaporation coefficient was little more than half that in the other two series and perhaps this may have had something to do with it. The heads as recorded were measured in the juice gage glass. The level of the juice, as viewed through the sight glasses, generally appeared higher than shown in the gage glass, the difference depending on the rate of evaporation. It may be possible that the actual head was greater than that recorded with the higher rates of evaporation, which would account for the difference betwen the theoretical and actual curves in A and B; also for the coincidence of the two curves in C, where the rates of evaporation were relatively small.

Effect of Temperature Levels Upon Heat Transmission

In order to get experimental data showing the variation in heat transmission at different temperature levels, three series of tests were made with the temperature in calandria varying between limits that would include the temperatures usually existing in the different calandrias of multiple evaporators. These three series are designated A, B, and C, respectively.

The A series was made with the calandria having no down take and with tubes 1⅜ in. x 24 in. (Fig. 3); the B series with the down take calandria having tubes 1⅜ in. x 24 in. (Fig. 4); and the C series with the 4-ft. calandria (Fig. 5). The average temperature fall was practically the same in each series, the principal variable being temperature in calandria, or, what is the same thing, pressure in calandria. All other conditions were kept as nearly constant during a series as was possible.

The effect of temperature level upon heat transmission is shown in Fig. 7. It will be noted that the direction and inclination of the three curves are quite similar, thus checking well. Assume that the temperature in the calandrias of the last bodies of doubles, triples, and quadruples are as marked 2, 3, and 4 respectively at the top of the figure—that is, 190 deg., 180 deg. and 175 deg.—also that 224 deg. is the temperature in the first body with either type.

From the three curves we find that the average coefficient of heat transmission in the second body of a double effect would be about 65 per cent. of that in the first body. In the same manner, the coefficient of heat transmission in the last body of a triple would be about 60 per cent. and in the last body of a quadruple about 58 per cent. of that in the first body.

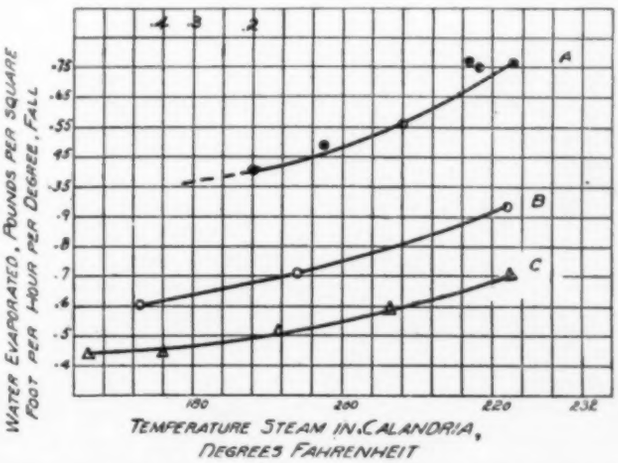


FIG. 7.—CURVES SHOWING THE INFLUENCE OF "TEMPERATURE LEVEL" UPON HEAT TRANSMISSION. WATER BOILED IN EACH SERIES

Four factors—viz., density of juice, cleanness of heating surface, air in steam, and density of steam or vapor—are possible causes of low coefficient of heat transmission in the latter bodies of a vacuum evaporator, but two of these factors were eliminated in these tests—viz., density of juice and cleanness of heating surface. Water was used during all the tests so that the density (also the cleanness of heating surface) remained unchanged throughout the series.

Thus the variation in the coefficient must be due to the variation in the quantity of air in the calandria, or to the variation

in the density of the steam or to both of them combined. It will be noted that the height in the three curves varies considerably. This is probably due to the fact that different types of calandrias were used in the three series.

Effect of Air in the Heating Steam Upon Heat Transmission

As explained in the preceding chapter, decrease of heat transmission in the latter bodies of multiple evaporators may be due to low steam density, or the presence of air in the steam or to both combined.

In an attempt to get further data upon this question and to determine, if possible, the proportion of responsibility of each of these two factors, a series of tests was made to determine the effect of air in the steam supplied to the calandria upon the coefficient of heat transmission.

In all of these tests the vacuum in the calandria was constant at about 12.5 in. and the vacuum in the vapor space about 22 in.; in fact, all conditions were kept constant, as nearly as possible, except the quantity of air with the steam in the calandria. To a casual observer it would have appeared that all conditions were constant.

The amount of air in the calandria was varied mainly in two ways—viz., by varying the speed of the condensate pump M (Fig. 1), and, where it was desired to admit large quantities of air, by opening very slightly an air cock connected with the manometer L.

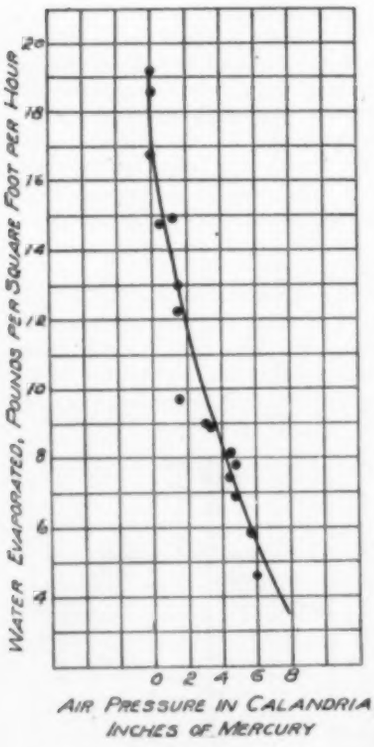


FIG. 8.—INFLUENCE OF AIR IN HEATING STEAM UPON EVAPORATING CAPACITY. WATER BOILED IN ALL TESTS

The amount of air in the steam was measured as follows: The temperature in the calandria was obtained by means of the two thermometers (J and K), one near the bottom and the other near the top. In preliminary experiments it was found that the average of the temperatures recorded by these thermometers was often lower than that of saturated steam corresponding to the pressure, as found in steam tables. It was also noted that this difference was greater when the condensate pump ran slow than when it ran at high speed, indicating that the presence of air had something to do with the reduced temperature in the calandria. It was also found that the temperature at the bottom of the calandria was often lower than at the top. The density of air is greater than that of steam, and the air naturally settles to the bottom, from whence it is removed by the condensate pump.

The method by which the quantity of air was measured was based upon Dalton's law, which states that "the pressure of a mixture of air or other gas and a vapor is the sum of the pressures each would have if it occupied the same space alone." In other words, the pressure or vacuum gage on the calandria shows the sum of the pressures due to steam and air. The temperature of the steam is that corresponding to its pressure, hence if the temperature of the mixture is known it is easy to find the partial pressure of the steam by referring to a steam table. By determining the pressure due to the steam in this manner and subtracting it from the sum of pressure as shown by the gage, the pressure due to the air is obtained. This method was used in the experiments, the average of the temperatures at the bottom and at the top of the calandria being taken as the temperature of the steam.

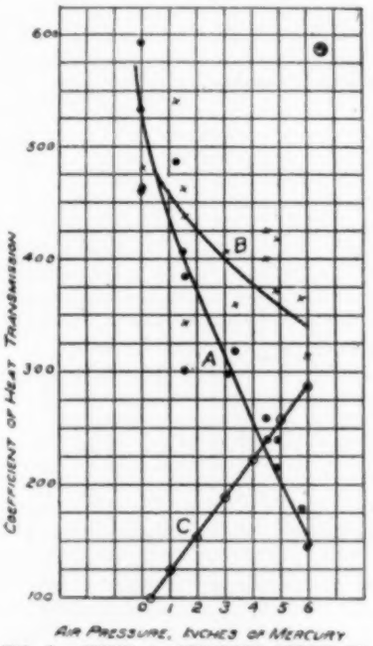


FIG. 9.—CURVE A, COMBINED EFFECT OF "AIR FILM" AND DECREASED TEMPERATURE FALL. CURVE B, EFFECT OF "AIR FILM." CURVE C, LOSS BY REDUCED TEMPERATURE FALL.

The most important results of these tests are shown in Fig. 8. (Evaporator, Fig. 2. Steam 12.5 in. vacuum. Vacuum in vapor space 22 in. Heat 12 in. Water boiled in all tests.) In order to fully realize the significance of the curve of Fig. 8 and the data from which it was plotted it should be remembered that the readings of the calandria vacuum gage and vapor space vacuum gage were the same in all of the tests. In addition to varying the speed of the condensate pump and admitting air through a pet cock, in varying the quantity of air in the calandria the injection of water into the suction pipe of the condensate pump was also employed. In order to get the most effective removal of air it was necessary to use injection in this manner.

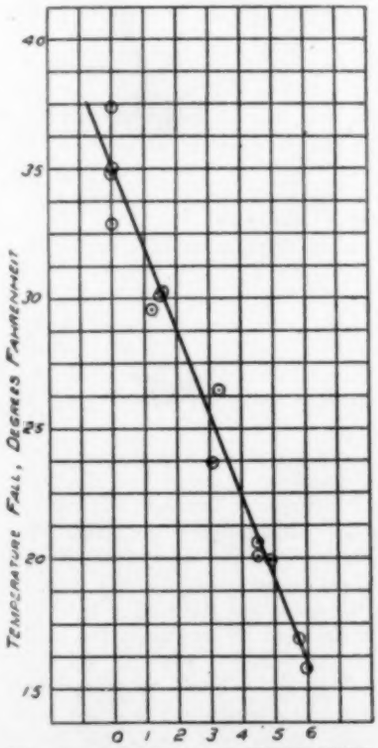


FIG. 10.—REDUCTION OF TEMPERATURE FALL AS AFFECTED BY AIR IN THE HEATING STEAM

Referring to the curve (Fig. 8) it is seen that the plotted points are very near the smooth curve, also that the decrease in capacity is very rapid with small additions of air, the evaporation varying from 4 to 19 pounds of water per square foot per hour, due to changing the air pressure from 8 to 0 in. of mercury. An air pressure equal to 1 in. of mercury caused the evaporation to be reduced from 19.2 to 14 pounds—that is, a reduction of about 27 per cent.

The effect of air in reducing the coefficient of heat transmission is shown graphically in the curves of Fig. 9. Curve A is based upon the coefficient of heat transmission calculated by dividing the B.t.u. transmitted per sq. ft. per hour by the temperature fall. It is the curve of "actual coefficient of heat transmission."

Curve B is based upon a slightly different calculation in that the B.t.u. transmitted per sq. ft. per hour is divided in each case by the temperature fall obtained by subtracting the temperature in the vapor space from the temperature corresponding to the pressure in the calandria instead of from the actual observed temperature, and will be designated as the "apparent coefficient of heat transmission" curve.

As will be seen, the reduction in capacity due to the presence of air is composed of two factors; viz., (1) a reduction in the temperature fall, as shown by Fig. 10, and (2) a reduction in the heat transmission per degree fall—that is, a reduction of the coefficient of heat transmission due to the nonconducting film of air next to the tubes.

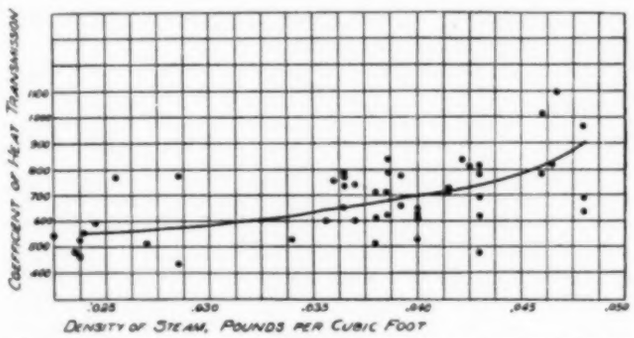


FIG. 11.—INFLUENCE OF STEAM DENSITY UPON THE COEFFCIENT OF HEAT TRANSMISSION

Curve *B* shows the latter quantity—that is, coefficient of heat transmission as affected by air pressure. Since curve *A* shows the total loss as affected by air pressure, it is evident that the loss due to reduced temperature fall is represented by the length of the ordinates between curves *A* and *B*. These values have been replotted and curve *C* drawn. This curve, therefore, shows the reduction in the number of B.t.u. transmitted per sq. ft. of heating surface per hour per degree difference due to reduced temperature, with varying air pressures.

Effect of Density of Steam

In order to analyze the effect of the variation of density of steam on evaporation some fifty-eight tests with heat transmission coefficients varying from 400 to 1100 and in which there was little or no air in the calandria were selected and coefficients of heat transmission plotted against density of steam. The curve in Fig. 11 is the result.

All of the tests selected were made with water instead of juice. In other respects, however, there was some variation of conditions, especially as regards head and type of calandria. For these reasons the points from which the curve was drawn are pretty well scattered though the general direction of the curve is rather definitely indicated.

The density of the steam is usually, say 0.024 in the calandria of the last body of a triple effect, and, say 0.045 in the first body. From Fig. 11 we find that the coefficients for these two densities are about 560 and 800 respectively. This indicates a great effect attributable to density of steam. The general correctness of the curve shown in Fig. 11 was checked in another manner given in the bulletin.

Effect of Density of Boiling Liquid

It is generally understood that the coefficient of heat transmission is greater with thin liquids and water than with denser liquids. This is, in all probability, due in part, at least, to the fact that with thicker liquids the circulation is not so good. Then, too, the resistance to the transfer of heat from metal wall to liquid is possibly increased by the greater amount of solid matter in the thicker liquids.

In order to isolate the effect of juice density upon heat transmission, two series of tests were made in which an attempt was made to keep all other conditions constant. The density of the juice was varied within limits that would include densities likely to be used in evaporators, viz., 8.8 Brix to 67.3 Brix. Series *A* was made with evaporator *B*, Fig. 3, that is, with the calandria having no downtake and with tubes 1⅜ in. x 24 in. Series *B* was made with evaporator *C*, Fig. 4, that is, with a calandria the same as the above except that it had a downtake in it. The results of these two series of tests are shown graphically in the two curves of Fig. 12.

It will be noticed that the two curves are parallel, thus checking well. That curve *B* is above curve *A* is doubtless due to the difference in the form of the calandrias used, the former having a downtake and the latter no downtake. With the downtake calandria-curve *B*, the coefficient of heat transmission for densities of 10 and 50 are 750 and 625 respectively, that is, 1 : 0.83.

Since the lower curve is parallel to the upper one, the ratio is practically the same for it. It should be mentioned that the reduction in heat transmission shown in this series is due solely to the increased density of the liquid and not to any fouling of the heating surface. The heating surface was clean in all of the tests.

Effect of Superheat in Steam on Heat Transmission

It is held by some that with superheated steam in the calandria, the coefficient of heat transmission is reduced. The superheat usually results when live steam is used, due to the reduction of pressure by throttling.

In order to obtain data regarding the effect of superheat, two series of tests were made, but the results of both tests seemed to prove conclusively that the coefficient of heat transmission is not affected by varying the superheat in the steam. According to this, live steam should give as good results as exhaust steam, as far as capacity is concerned.

Value of the Downtake

"Most evaporators of the standard type are now built with downtakes—that is, with a large central tube, the diameter of which depends on the diameter of the body itself. Some few builders, however, claim that there is little merit in downtakes and do not use them. The advantage claimed for the downtake is that it adds in juice circulation—that is, it defines the path of circulation—and in this way increases the velocity, the movement being always downward through the downtake and upward through the tubes. Some few have claimed that the transverse area of the downtake should be equal to the combined transverse area of all the tubes. This, however, would result in a very large diameter of body and high first cost. In average practice the

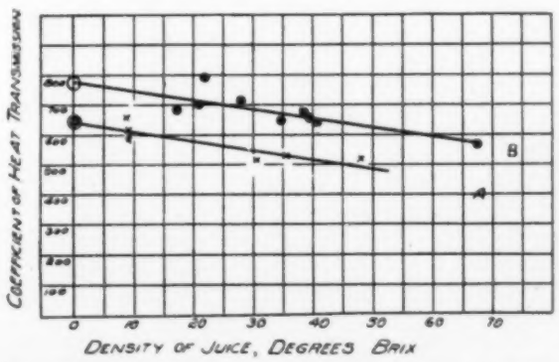


FIG. 12.—INFLUENCE OF DENSITY OF JUICE. CURVE A: EVAPORATOR WITHOUT DOWNTAKE. CURVE B: EVAPORATOR WITH DOWNTAKE

diameter of downtake for, say, an 11 ft. body would be 34 in. to 38 in. in diameter and this would give the downtake a transverse area of about 18 per cent of the total transverse area of the tubes."

In order to get data on this subject, two calandrias (Figs. 3 and 4) were constructed, one with a downtake 6 in. in diameter and the other without a downtake. They were alike in every other respect. The calandria with the downtake had 66 tubes

of 1⅜ in., the total transverse area of which was, therefore, 87.6 sq. in. The area of the downtake being 28.3 sq. in., was 32 per cent of the area of all the tubes.

Several series of tests were made with these two calandrias under conditions such as will make comparisons of the heat transmission in them possible. The different tests given in the bulletin show clearly the value of the downtake in increasing the heat transmission coefficient. Fig. 12 given before shows this in the two curves *B* and *A*, in which *A* refers to the evaporator without downtake and curve *B* refers to evaporator with downtake. The coefficients of heat transmission for the calandrias with and without downtakes are, therefore, in the ratio 100 : 83. Without going into any further details on this subject the final conclusions of the authors may be quoted.

"Tests on two calandrias, alike except that one had and the other had not a downtake, showed that the coefficient of heat tranmission was 20 per cent greater in the downtake calandria.

"The net increase in evaporative capacity of the downtake calandria over that without a downtake, after accounting for the reduced heating surface in the downtake calandria, was 19 per cent.

"It is likely that this increase of the transmission coefficient is due to the improved circulation due to the downtake."

Dimensions of Tubes

Tests upon two calandrias, one with tubes 1⅜ x 24 in. and the other with tubes 2 x 48 in., seem to show that the coefficient of heat transmission was about the same in both.

The 48-in. tube probably has the advantage of more rapid circulation than the 24-in. tube, while, on the other hand, it has the disadvantage of having to be operated with greater juice head; perhaps also with greater water flooding of the heating surface.

Entrainment

As already explained, any juice carried over by entrainment was caught in the separator or catchall *Q* (see Fig. 1). This separator used in the tests was the Swartwout separator of the Ohio Blower Company. It is shown in section in Fig. 13.

This separator is designed for use as an oil separator between steam engines and surface condensers. Thus it will be seen that the conditions for which it was designed are similar to those in vacuum sugar apparatus.

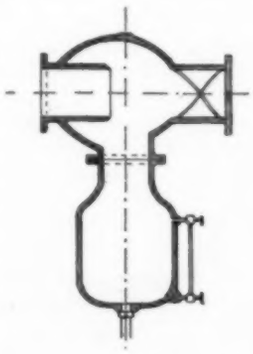


FIG. 13.—CATCHALL

The separation of liquid from steam is effected by centrifugal force. The mixture of steam and liquid upon entering the separator is given a whirling motion by means of the spirals shown in the figure. This whirling motion causes the heavier liquid particles to be thrown to the circumference, from whence it drains down to the receptacle at the bottom. The liquid caught in the separator was removed from the separator during the operation of the evaporator, if necessary, by means of the two valves *U* and the long pipe.

The vapors passing on through the separator were condensed in a surface condenser, hence the condensed vapors were not diluted by direct contact with the cooling waters. This made possible more accurate determinations of the sugar lost in the same.

The object of the entrainment tests was to determine the effect upon entrainment due to varying the rates of boiling, the height of boiling, the length and diameter of tubes, the vacuum and velocity of vapors in the vapor space, and the density of the juice.

The results of these entrainment tests are summed up as follows:

Entrainment was found to vary mainly with the weight of water evaporated per square foot of heating surface per hour (rate of evaporation) with the height of boiling and with the dimensions of the heating tubes.

With the downtake calandria the maximum entrainment was at the rate of 27.5 pounds of juice per hour, with an evaporation rate of 17.6 and a juice head of 26 in.

With low heads (12 in.) evaporation rates of 23 were maintained with practically no entrainment.

With the 24-in. calandria without a downtake the sugar caught in the separator varied from 0 to 44.7 lb. per hour. In one series, where the average rate of evaporation was 18, the average weight of sugar entrained was 0.46 lb. per hour, corresponding to 27.6 lb. per hour in one body of a 10-ft. standard, the head being 16 to 24 in.

With the same calandria another series of tests, with an average evaporation of 10 lb. and with heads of 16 to 24 in., gave no entrainment.

The maximum entrainment (average of four tests) with this calandria was 30 lb. per hour, with an average rate of evaporation of 25 and an average juice head of 19 in. In one test an evaporation rate of 27 was maintained without entrainment. This was due to the low head of 12 in.

The maximum evaporation rate possible with this calandria without entrainment is probably about 22, this being the average of five tests, in which there was no entrainment.

The maximum entrainment with the calandria having tubes 2 x 48 in. was 24.3 lb. of sugar per hour, with an average evaporation rate of 12.4 and an average head of 26 in., this being the average of three tests.

The average evaporation rate of a number of tests on this evaporator, all of which were near the entraining point, but in which there was actually no entrainment, was 7.8.

Thus it seems that the calandria with tubes 2 x 48 in. cannot be forced to more than half the rate that is possible with 1⅜ x 24 in. tubes without entrainment.

By keeping the juice level low relatively large capacities are possible in either type of calandria without entrainment.

Neither the vacuum in the vapor space nor the velocity of vapors in the vapor space seem to affect entrainment to any measurable extent.

The tests do not furnish data regarding the effect of juice density upon entrainment. If entrainment is influenced by density at all it is probably in the fact that the greater the density of the boiling juice the greater the density of the juice caught in the separator and, therefore, the greater the amount of sugar.

The separator used was very efficient, a slight trace of sugar being shown in the condensed vapors in only one test.

In all other tests, even where large quantities of juice were caught in the separator, no trace of sugar was shown by the alpha-naphthal test.

The loss of pressure due to the friction of the vapors in passing through the separator was 0.5 in. water, with a velocity of 7940 F.P.M., an amount practically negligible.

While the above gives a concise summary of the contents of the bulletin anyone who is especially interested in problems of vacuum evaporation will find the whole bulletin interesting and profitable reading.

Professor Kerr and Mr. Isacks are to be heartily congratulated on the elaborateness of the tests and the success obtained and their future investigations will be awaited with interest.

A New Dry Mixer.—The thorough mixing of such materials as fertilizers, fuel ores, the ingredients for glass, dry plaster materials, etc., in fact, every material which is dry and dusty, is now being accomplished by many manufacturers by the use of specially designed dry mixers. For this purpose the Ransome Concrete Machinery Company, Dunellen, N. J., are building a dry mixer which is of the same principle as that of their concrete mixer, which has been so widely used all over the world, with the exception that the drum is sealed, thus preventing the escape of dust during the mixing process.

Methods for Investigating and Recording Atmospheric Impurities, Including the Soot and Dust Suspended in the Atmosphere

By John B. C. Kershaw

One of the most important *Resolutions* passed at the International Smoke Abatement Exhibition and Conference, held in London in March, 1912, was that relating to the framing of a standard method of catching and measuring the more commonly occurring impurities of the atmosphere. This resolution was worded as follows:

Atmospheric Pollution.

"That in the view of this conference, it is desirable that immediate steps should be taken, to decide upon and secure the general adoption of a standard method for the measurement of atmospheric pollution by smoke, and the other products of combustion and dust, in order that the data now being collected may possess a comparative value, and that a committee be appointed to draw up details of a standard soot and dust measuring apparatus and methods of its use.

"That the committee do consist of Dr. H. A. Des Voeux, M. D. (Hon. Treasurer, Coal Smoke Abatement Society); Prof. J. B. Cohen, B.Sc., Ph.D., F.R.S. (Leeds University); Bailie W. Smith (Covener of the Air Purification Sub-Committee of the Glasgow Corporation); Dr. Hawksley (Assistant Medical Officer of Health, Liverpool; Mr. J. B. C. Kershaw, F. I. C. (Hamburg Smoke Abatement Society); Dr. John S. Owens, M. D., A. M. I. C. E. (Coal Smoke Abatement Society); Dr. W. N. Shaw, M. A., D. Sc., LL.D., F. R. S. (Director, Meteorological Office), and Dr. S. A. Vasey (*The Lancet*), with power to add to its number. Subsequently added: Dr. R. Lessing, Ph.D., F. C. S.; Mr. E. D. Simon (Smoke Abatement League of Great Britain), and Mr. J. G. Clark.

"That the conclusions and recommendations of such Committee be reported to the Delegates forming the Conference and to all Municipal Authorities in the United Kingdom."

The Committee, since its appointment, has held three meetings in London, and has given careful consideration to the various methods that have been suggested or tried for the collection and estimation of atmospheric impurity. The following is a list of the various methods which received consideration, with some notes upon the places where they have been tried and upon their relative advantages and disadvantages.

It was decided that the method selected as best must fulfil the following conditions:

(1) It should measure the actual amount of suspended matter in the air, not the amount relative to other places, i. e., it should give the pollution in, say, grams per cubic metre.

(2) The foreign matter or impurity should be collected in such a way as to permit of analysis.

(3) It should be as simple as possible, provided conditions (1) and (2) are fulfilled.

Methods that Have Been Suggested or Tried

I. Filtration of a measured volume of air through a cotton-wool or collodion-wool filter and examination of the deposit.

This method has been used by Russell in London and by Hahn in Germany and can be made to give good results. With care condition (1) can be be fulfilled and when collodion-wool is used it can be made to satisfy condition (2). It requires, however, costly apparatus and considerable technical skill, and it possesses inherent defects if a color scale be employed as measure or gauge of the amount of deposit.

II. Collection of rainfall; evaporation and weighing of residue.

This method was used in the investigations started by Dr. Des Voeux and *The Lancet* in 1910 in order to obtain the soot-fall of London. It was also employed by Professor Cohen in Leeds about the same date. The method does not, strictly speaking, give the amount of air pollution, but the amount which falls on a given area (a) in rain, snow, etc.; (b) during dry weather, (a) and (b) are not separated. The apparatus used for collection of the impurities may be very simple, and the technical work can be done in a central laboratory.

III. Aitken's dust counter.

This was devised by John Aitken for counting the number of dust particles in the air. The method and apparatus satisfy condition (1), but not (2).

IV. Exposure of glass plates to the air for a specified time, followed by washing in water, and measurement of the adherent deposit that remains, by comparison with standard colors.

This method has been used by Professor Cohen in Leeds for catching the matter which will adhere to a glass plate, e. g., tarry soot. It would seem that the thickness and color of the deposit must be affected by the amount of tar present in the smoke of the city. The method aims only at comparative results, and does not fulfil either condition (1) or (2).

V. Exposure of glass plates coated with a drying oil, to a stream of air; or to the atmosphere, either (a) for a fixed time, followed by a measurement of the opacity by comparison with a calibrated scale, or (b) for such time as will produce a fixed opacity, and comparison of the time required with a calibrated time scale.

This method has been used by Cohen in Leeds and in Hamburg by Liefmann, and it might possibly be made to fulfil conditions (1) and (2). It requires, however, elaborate apparatus, and some technical skill in its use, and it is not suitable for application on a large scale and under the conditions which will obtain for the Committee's observations.

VI. The air is drawn at a measured rate through a filter-paper, and the degree of blackness produced in a given time is then measured.

This method has been used by Rübner in Germany and by Bailie Smith in Glasgow. It gives results which depend upon the color of the matter caught, as well as upon its amount. Condition (2), however, would be fulfilled.

VII. Measurement of the transparency of a column of air of given length, when illuminated with a standard light.

A modified form of this method has been used for observations of the smoke from chimneys in many towns. The method could probably be arranged to fulfil condition (1) by measuring the transparency of air holding in suspension known amounts of matter, but it would not fulfil condition (2).

VIII. The rainfall is caught, and its transparency is compared with a standard scale of values, made by adding definite quantities of soot to distilled water.

This method is open to the same objection as the second method: neither does it fulfil condition (2). The results would depend also on the nature of the impurity, as well as on its quantity.

IX. Dust-boxes are exposed, having a collecting surface of one square foot.

These boxes have been used by Chief Inspector Fyfe in Glasgow and Aberdeen, and are simply a less accurate means of operating the second method.

As already stated the respective advantages and disadvantages of the above nine methods were fully considered by the Committee before coming to a decision, and it was finally decided to adopt Method II, namely, that used by Professor Cohen and by Dr. Des Voeux and *The Lancet* for the investigations upon the soot-fall of Leeds and London, carried out by them in 1910.

A Specification for a *Standard Form of Apparatus and Rules* for the collection and examination of the deposit, have been drawn up.

The standard instrument consists of a circular open-topped gauge-vessel, supported in a galvanized iron frame. This frame is provided with a shelf for carrying a bottle to contain the rain-water which enters the gauge. The gauge-vessel is constructed of cast iron enamelled with a vitreous insoluble enamel. It is of importance that the superficial area of the top of the vessel (included inside the sharp edge) should be constant in all vessels, thus assuring the same catchment area in

each. To provide for this the top edge of the vessel must be machined before enamelling. Fig. 1 shows one of the soot gauges used for the London observations in 1910 with the gauge-vessel and bottle in position. Fig. 2 is a section of the standard gauge-vessel alone, removed from its frame, and Fig. 3 is a plan of the standard gauge. A well-fitted glass strainer is provided as shown.

The stand is formed of the four angle iron legs riveted at the top to two iron rings, the lower of which is to be of suitable size to receive the gauge-vessel and support it. To the upper ring are attached galvanized iron wires of 14 S. W. G. These are fixed at their lower ends to a ring of 1/16" galvanized iron riveted between the legs and the heavier ring which supports the gauge-vessel. A cage is thus formed surrounding the gauge-vessel, but opens at the top. A shelf of 1" pine is provided at the bottom, the boards being screwed to 1½" x 3" battens which fit inside the iron supports riveted to the legs. All metal except the gauge-vessel is galvanized iron.

Each instrument is provided with four bottles of stock pattern and of a capacity of about two gallons each, and having

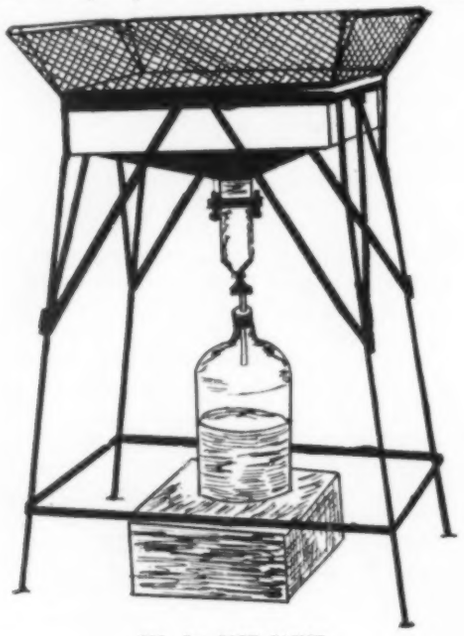


FIG. 1.—SOOT GAUGE

rubber bungs, one of which is fitted with holes for the glass tubes.

As regards the method of using this standard gauge, the following preliminary instructions have been drawn up by the committee:

1. All gauges are to be placed on the ground level, in an open space free from abnormal dust.

2. The bottles containing the water and deposit are to be removed on the last day of each month, and thoroughly cleaned empty bottles are to be substituted.

3. Before removing the bottles for analysis, the gauge-vessel is to be washed down with some of the water already collected, a brush of standard pattern being used to remove any adherent matter.

4. A chemical analysis of the water and deposits is to be made by a standard method, particular attention being given to obtaining the relation between the quantity of tarry oils present and the amount of free carbon.

The examination of the solid matter contained in the bottles may be confined simply to the determination of the total solids (which can be separated either by evaporation or by filtration), or it may cover detailed separation of the soluble and insoluble portions of the impurities collected from the atmosphere by the rain-fall. A sub-committee is at present dealing with the framing of a standard method of examination. This will be used for the observations which are to be carried out under the auspices of the Committee.

For the *Lancet* observations, carried out in London in 1910 at three stations in the London area, the following constituents were determined: Total solids, insoluble deposit, soluble deposit, soluble volatile solids, soluble fixed solids, sulphate am-

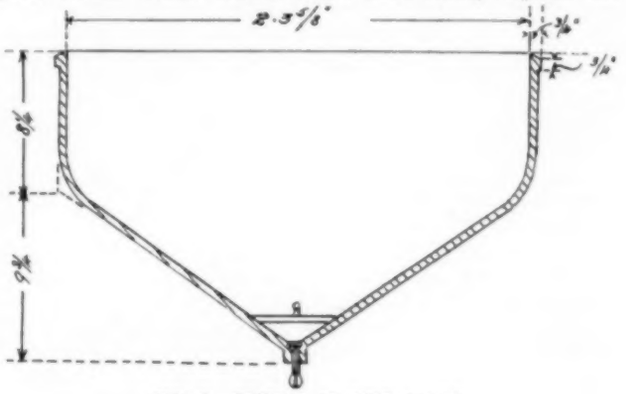


FIG. 2.—SECTION OF SOOT GAUGE

monia, chloride. The Table presented below summarizes the results obtained.

The *Lancet* inquiry was confined, as already stated, to

LONDON'S COAL SMOKE DEPOSIT

Observation Station	1 Litres of Rain	2 Total Deposit	3 Insoluble Matters	Soluble Matters 4 Total	5 Fixed	6 Volatile	7 Sulphate SO_3	8 Ammonia NH_3	9 Chlorides Cl	Total Deposit per Square Mile
A. Buckingham Gate, S.W.	201.1	71.985	46.335	25.650	13.311	12.339	6.017	5.013	5.699	500
B. Horseferry Road, S. W.	192.0	60.339	33.490	26.849	12.324	14.525	5.942	5.133	4.094	420
C. Old Street, E. C.	192.0	92.813	60.920	31.893	19.242	12.651	10.043	7.542	4.033	650
D. Sutton, Surrey	210.5	27.894	8.365	19.529	8.723	10.806	0.892	0.347	2.163	195

NOTE.—All results in columns 2 to 9 are expressed as grammes, and represent the totals obtained from the 4 square feet of catchment area, over the 12 months of observation.

observations made at three London stations and to one in the suburban districts of London (at Sutton in Surrey), and its

FIG. 3.—PLAN OF SOOT GAUGE

value for comparative purposes was, therefore, less than would have been the case if similar results had been available from

other cities and towns. The Committee appointed at the International Smoke Abatement Conference of March, 1912, therefore decided to communicate with all the principal local authorities in the United Kingdom, and to ask for their co-operation in an organized attempt to collect reliable data by means of the apparatus and methods of examination approved by the committee for this purpose. It was believed that many of these authorities would welcome the introduction of a standard method of conducting such observations, and that the results would prove of much greater practical value than any number of independent inquiries based on the use of different apparatus and different methods of observation. A circular letter sent out by the Committee in January, 1913, proved that this opinion was correct, and it is now practically certain that the following important cities of the United Kingdom will commence these observations on or before October 1 of the present year, using the standard apparatus and method recommended by the Committee: London, Liverpool, Manchester, Glasgow, Birmingham, Newcastle, Bradford, Hull, Leicester, with others that are now considering the proposal.

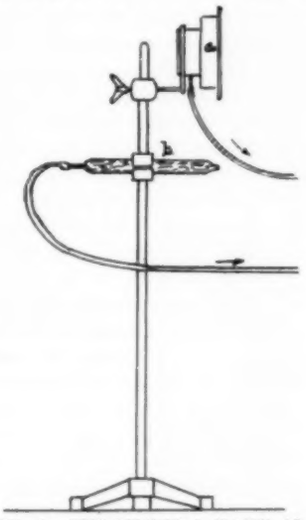


FIG. 4.—THE RUBNER & HAHN APPARATUS

The results of the observations in each city or district will be passed on regularly to the London Committee, and an annual report will be published containing all the figures and the conclusions which the Committee arrives at as to the practical progress of the smoke abatement movement in the various cities and towns from which the returns are sent.

Other Methods of Observation.

Turning now to a consideration of the other methods for collecting and examining the solid impurities of the atmosphere, those of Rübner, Renk, Hahn, Liefmann, Cohen and Fyfe will be briefly described.

Rübner's Method.

The Rübner method of soot and dust determination is based upon the aspiration of a large volume of the air which is to be tested (200-300 cubic feet) through a filter paper placed in a special holder, Fig. 4. Upon the surface of this paper the soot and dust are collected. The aspiration is effected by a water-jet pump, the volume of air being measured by an ordinary dry meter. The determination of the amount of soot and dust collected on the paper in 12 or 24 hours is carried out by comparison with a standard scale, since the amount is too small even with a large volume of air used to be determined by direct weighing. Renk has employed for the comparison a mixture of a known amount of soot and oil, which when used in a wedge-shaped glass vessel, gives a color scale of gradually increasing density. This method of estimating the soot and dust in the atmosphere was employed in 1909-1910 by the officials of the Hygienic Institute in the city of Hamburg, the apparatus being installed at five different points in the city. The results of the investigation will be found summarized in the report for the year 1910 of the the Hamburg Smoke Abatement Society.

Hahn's Method.

The apparatus devised by Hahn consisted of a filtering tube and of a double-cylinder pump worked by an electric motor provided with current from accumulators. The volume of air in this case was ascertained by multiplying the cubical capacity of the two cylinders of the pump by the number of revolutions of the crank shaft as recorded by a counter attached to the same. The soot and dust were retained by drawing the air through a tube containing collodion-wool, shown in Fig. 4.

The weight of solid matter was estimated by dissolving the collodion-wool with its deposit of soot and dust, in a mixture of two parts of ether and one part of alcohol. The final step was to compare the turbid fluid thus obtained with various standard solutions containing collodion and known amounts of impurity.

Liefmann's Method.

Liefmann's method differs essentially in principle from the two methods described above since it is based upon "sedimentation" of the soot and dust particles, upon prepared plates, and not upon filtration. The method is described in considerable detail in the thesis published by Liefmann, on taking his doctor's degree at Halle University in 1907. Considerable space is devoted in this pamphlet to the theory of sedimentation as a means of measuring the soot and dust particles suspended in the air; and to the various reasons why two surfaces are necessary (a vertical one and a horizontal one) in order to obtain correct results. The practical operation of the method only can be described in this article. The apparatus required (Fig. 5), is simpler than in the case of the Rübner and Hahn method, and it is therefore more easily moved from place to place, or erected in any desired point of observation.

A firm three-footed base of cast iron, provided with a vertical rod or spindle carries a horizontal plate, upon the edges of which are fixed four thin uprights, carrying a light roof or cover. Under this cover is fixed the vertical disc of glass, covered with a thin film of oil, for catching the drifting particles of soot and dust. These drifting particles would not be caught by the horizontally placed disc, and in this respect Liefmann's apparatus and method, with a vertical as well as a horizontal disc, differs from that used by Cohen for the observations carried out at Leeds, and reported in the Proceedings of the Smoke Abatement Conference held in Manchester in November, 1910.

The results obtained by Liefmann at Hamburg cannot, therefore, be compared with those obtained by Cohen at Leeds, although obtained by a method depending upon the same principle of sedimentation. This defect in the two sets of observations shows how necessary it is that some standard method and apparatus should be used, in order to obtain the greatest value from observations upon the soot and dust falls in the various centers of population and industry.

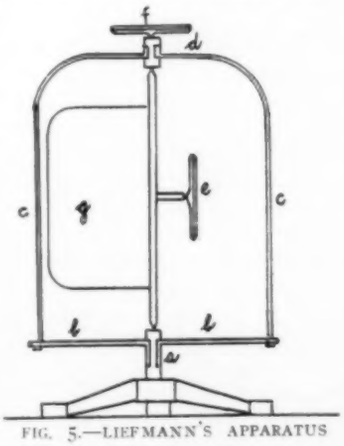


FIG. 5.—LIEFMANN'S APPARATUS

Liefmann's observations were carried out in Hamburg in the winter of 1903-1904 and the total deposit varied between 16 and 299 milligrams per square metre of exposed surface per 24 hours according to the direction of the wind and humidity of the atmosphere. These totals are equivalent to 15 tons and 283 tons per square mile per annum.

Cohen and Ruston's Apparatus and Methods.

The observations upon the pollution of the atmosphere in Leeds (referred to above) were carried out by three methods which are similar in principle to those that have been described. In one set of observations the rain-fall was collected, and the insoluble and soluble impurities were separated and examined.

This is the method that has been selected by the London Committee for its investigations, and the only improvement they have made in Cohen's apparatus is that of increased size, the funnel or collector having an area of 4 square feet, instead of 0.7854 of a square foot.

In another set of observations snow was collected after a

heavy downfall, and the amount of solid impurities it contained was estimated. The third set of observations were made by the sedimentation method, clean glass plates one foot square being exposed horizontally, and the sticky, tarry matter which adhered to them being weighed. Cohen and Ruston's figures for the soot and dust fall of Leeds and the surrounding suburbs varied from 25 to 539 tons per square mile per annum, the lowest figures being that of Roundhay (a country district to the southwest of the city), and the highest figure that of 539 tons for Leeds Forge, in the heart of the manufacturing district of the city.

Fyfe's Method.

During the winter of 1910-1911, Chief Inspector Fyfe, of the Glasgow City Sanitary Department, carried out a series of observations upon the soot and dust fall in Glasgow and other Scotch towns, by means of "atmospheric dust-boxes." These boxes were shallow wooden boxes, one foot square in superficial area and one foot in depth. They were exposed on the roofs of buildings in suitable situations, at a height of 30 to 35 feet above the ground. After two months' exposure the boxes were collected and the contents were carefully weighed and analyzed by the Glasgow City Corporation Chemist. The figures obtained by this very simple and crude method varied from 2.27 cwts. per area per annum at Bo'ness on the Firth of Forth, to 19.6 cwts. per acre at Falkirk, equivalent to 72 and 627 tons per square mile, respectively.

Benner's Method.

For the smoke investigation which is now being carried out by Benner and others in U. S. A. under the auspices of the Department of Industrial Research of the University of Pittsburg, Benner has used glass cylinders 4 inches in diameter and 10 inches deep, which are exposed on the roofs of buildings four stories high, in various parts of the city. The water and dust which are collected in this way are evaporated to dryness; the insoluble residue is then weighed and extracted with ether. From the percentage of tar obtained in this manner that part of the total solids due to soot can be calculated. No figures have yet been published for the results of the Pittsburg observations.

Notes on Chemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

Institution of Mining and Metallurgy.

At the last meeting of the Institution of Mining and Metallurgy Mr. **Herbert K. Scott** read a paper on "Bulgarian Mineral Deposits," and said hitherto mining in Bulgaria could not be accounted very successful, although a favorable mining code and a sympathetic government had greatly assisted it. But when the war, the fear of which had for many years deterred commercial enterprises, shall have been concluded, it is only reasonable to suppose that the development of the mining resources of Bulgaria would be rapidly and successfully achieved. In ancient times the mines of Bulgaria appeared to have played an importnat part, if the extent of the old workings and the accumulation of slag at various points were any criterion. But until 1878 they were almost neglected.

The State in that year began operations on a lignite formation near the village of Mochino, about eighteen miles from Sofia, and the output was entirely taken up locally. Another lignite deposit in the same district was started on in 1891. The mining law of 1892 made generous provisions and considerable activity resulted; and from that year up to 1907 a great number of prospecting licenses was given, and some thirty-one mining concessions were granted by the government during the same period. The State reserved to itself the lignite formations Pernik-Mochino-Vladja and Bobov-dol, south of Sofia, as well as the Belnorvh coal deposits in the central Balkans, and the deposit of lead in the Rhodope mountains near Lacavitza. Although a large number of licenses and concessions was granted, operations were being carried on in only three mines in 1909; namely, at Pernik, near Sofia, for lignite; at Plakalnitza, near Vratza, for copper ore, and at Blagodat, near Kustendil, for lead, copper and zinc.

Mr. **F. White** discussed "Errors in Sampling and Assaying Ores Due to the Presence of Coarse Gold." He contended that the discrepancies which frequently existed between the quantity of gold actually recovered and the quantity which should have been recovered by direct cyanide treatment of low grade gold ore demanded a complete investigation of the circumstances affecting the estimate of the gold contained in the charges and also of that remaining in the residues. The author decided that the cause of the variations shown in triplicate assays must be looked for in the final sample.

After careful examination it was found that the variations were mostly due to the presence in some of the samples either of coarse grains of gold or of flaky re-precipitate gold; but these particles were not distributed through the whole of the charge of ore in the same proportion as in the ore used in the fusion. This was more noticeable in the charge than in the residue, because the large grains of gold would mostly be dissolved by the cyanide treatment.

Tests were made to ascertain whether the grain or two of coarse gold which might have given a high figure in one of the triplicate assays existed in the same proportion in the whole of the charge, or whether those grains were infrequent. From these experiments the author concluded that where there were only a small number of gold grains of unusually large size, the assay sample should be passed through a 30 or 40 mesh sieve only. Triplicate fusions should be made; and where any serious variations occurred they should be repeated. Abnormally high results should be rejected in taking the averages. In such cases it was reasonable to conclude that there would be a tendency for the "average" to exceed the real value.

Institution of Mechanical Engineers.

In his recent presidential address Sir **H. F. Donaldson** dealt largely with the conditions necessary for the advancement of the Institution and the necessity for practical training. He said that the recent action of the Institution in deciding to ascertain by examination the extent of the scientific knowledge possessed by candidates for admission as graduates or associate members would in the future have a very wide effect. A system of examination was at present the only means of ascertaining the candidate's knowledge; but for a practical profession like theirs it was always open to suspicion that the knowledge shown by examination was not of that stable character which was desirable, but might have been obtained by the pernicious process of cramming. It rested, therefore, with the Council and its collaborators to arrange the examinations so as to prevent as far as possible the system of cramming, and to make sure that the knowledge displayed by the candidates was sound.

He was inclined to take teachers to task for some of the advice they gave explicitly or tacitly to students. Many young men had the idea when they had gone through a course of technical study and had possibly displayed great ability, that that, and that alone, entitled them to look for a good position in engineering works. That idea was quite erroneous unless they had had practical instruction as well. It would probably be found that employers looked on such half-trained men with suspicion, and might have actually suffered from engaging such men, and might have been led to say that although they wished to have men trained both theroretically and practically they could not employ a man who had theoretical knowledge only, and that if they could only get men trained on one line they would take the practical man and not the theoretical.

The President personally desired the services of men who were thoroughly trained, because he had had experience of their value; but he was sorry he could also speak from experi-

ence in saying that the practical workshop was too often neglected, and he was certain that the omission of that was disastrous to the student himself as well as to his profession. Some of the blame must attach to the teachers, and he hoped that any who were responsible, directly or indirectly, would recognize that if they desired, as, of course, he thought they did, the co-operation of employers in advancing the interests of their students, they must avoid the inculcation of such wrong ideas and impress on their students that to be qualified for a practical profession they must go through a thoroughly practical as well as a thoroughly theoretical training.

It would seem that those who were responsible were teachers who had not themselves gone through the workshops, or if they had had taken up with teaching before gaining adequate practical experience. Such men would be thoroughly conversant with theory and fully competent to teach on this side of the subject, but when they lacked practical training it was inevitable that they lacked also the power of imparting knowledge of the application of theory to practice. He felt strongly that a man with only technical and no practical training was a long way off from being a practical engineer; and also that a man with practical and no technical training was not sufficiently equipped to carry out the engineering work of today.

The Institution should not concern itself solely with its internal affairs. Just as each man had duties to the State, to his profession and to his institution, so the institution had similar duties, and its work should include not only its own interests but also the throwing open to the general advantage the results of its work. Of course some *kudos* attached to successful work when its useful results were fully published, but the institution should be willing to forgo that *kudos* if by combination with other institutions better co-ordination could be obtained. The institution spent a certain amount of money on research, and it was possible that part of the money which they devoted to individual research might be better spent in supporting the work of a central engineering research committee, and that other institutions might also be willing to make grants for a similar object. The advantages which would result from this course would be the prevention of a considerable amount of over-lapping work, individual research would be carried out to definite results, such results would be published and such publications would include accounts of private researches conducted by those who associated themselves with the engineers' research committee.

Engineering Imports and Exports.

The returns issued by the Board of Trade for the three months ended on March 31 show very satisfactory advances, except in imports of electrical goods and new ships, as compared with the corresponding period of last year. Iron and steel, including manufactures, were imported to the value of £3,967,789, an increase of £1,057,893, and were exported to the value of £13,321,611, an increase of £982,293. Imports of other metals, including manufactures, amounted to £8,220,904, an increase of £547,752, and exports totalled £3,429,356, an increase of £576,751. In electrical goods the imports were £374,339, a drop of £36,922, but exports rose to £1,540,256, an increase of £349,518. Imports of machinery figure at £1,833,892, a rise of £201,409, and exports went up to £8,590,063, an increase of £777,593. Imports of new ships are put at £2,900, a decrease of £7,967, while exports are valued at £2,039,490, an improvement of £863,761.

Taking the returns for March by themselves, imports of iron and steel rose by £396,196 and exports by £23,071; imports of other metals increased by £103,862 and exports by £32,935; imports of electrical goods fell £19,080 but exports rose by £153,015; imports of machinery were £31,975, but exports dropped £34,212; imports of new ships declined £9,472, while exports showed an improvement of £452,054.

Market Prices, April, 1913.

Copper was a rising market until the 14th, when it touched £69; has since been weaker. Opened at £66, closes £67.10.0.

Tin has been on the whole a rising market, fluctuating up to £231½ (18th); it closes £227½.

Lead rising the first half of the month from £17 to £19, it has afterwards been easier, closing slightly lower at £18.10.0.

Haematite has been very steady at or about 79/-, at which price it closes.

Scotch Pig showed depression from 3rd to the 14th, then recovered on 18th, and since stronger closes 73/3.

Cleveland has been through the same fluctuations as Scotch Pig. It closes 67/3.

	£ s. d.
Aluminium, ton (ingots)	95. 0. 0
Alum, lump, loose, per ton	6. 0. 0
Antimony, ton	20. 0. 0
Borax, British refined, crystal, ton	17.10. 0
Copper ore, 10 to 25%, per unit	12/4½ to 12.10½
Copper sulphate, per ton	23. 7. 6
Carbolic acid, liquid, per gal	1. 4
Creosote, ordinary, good, liquid, per gal	2⅞
Caustic soda, 70%, per ton	9.12. 6
Ebonite rod, per lb	4. 6
Hydrochloric acid, cwt	5. 0
India rubber, Para, fine, lb	3. 4½
Mica, in original cases, medium	3/6 to 6. 0
Naphtha solvent, 90% at 160° C	10½
Petroleum, Russian spot	9¼
Quicksilver, per bottle	7.10. 0
Sal-Ammoniac, lump, 1st delivered U. K. per ton	44. 0. 0
Sulphate of ammonia, f. o. b. Liverpool, per ton	13.17. 6
Sulphur, recovered, ton	5. 5. 0
Shellac, per cwt	4. 5. 0
Platinum, oz.	9. 5. 0
Tin ore, 70%, per ton	148 to 150. 0. 0
Zinc, Vielle Montagne, f. o. b. Antwerp, per ton	28.12. 6

Higher.	£ s. d.	*Lower.*	£ s. d.
Aluminium	6. 0. 0	Caustic soda	7. 6
Alum	10. 0	Ebonite rod	9
Copper ore	9	India rubber	7½
Copper sulphate	7. 6	Quicksilver	5. 0
Petroleum	1	Sulphur	5. 0
Sulphate of ammonia	7. 6		
Tin ore	5. 0. 0		
Zinc	5. 0		
Copper	2.12. 6		
Tin	9.10. 0		
Lead	1.18. 0		
Cleveland	6. 0		

Recent Chemical and Metallurgical Patents

Iron and Steel

Electric Steel.—Another patent has been granted to Mr. WILLIAM R. WALKER, of the United States Steel Corporation, for the combined Bessemer converter and electric furnace steel process. The particular feature of this patent is the re-carburizing of the metal decarbonized in the Bessemer converter, the re-carburizing taking place in the ladle before the metal is transferred to the electric furnace. The process is in detail as follows:

Molten pig metal is introduced into a Bessemer converter and blown until the silicon has been eliminated and the carbon reduced to a definite percentage, preferably to about 0.05 per cent, which percentage can be gaged with accuracy because it is about the percentage contained in the metal at the time when the flame "drops," a phenomenon which is well known and readily recognized by the skilled blower. The disiliconized and substantially decarburized metal a proportion of carbon is then added sufficient to raise its carbon content to a definite percentage, preferably to about 3 per cent, though this percentage may be varied. The carbon addition is made by adding to the Bessemer metal in the ladle, pig iron either in the form of cold pig or molten pig, and as the percentage of carbon of

the Bessemer metal is substantially constant, the amount of pig metal to be added in the ladle can be readily determined with substantial precision. The carbon may be introduced by adding anthracite coal or powdered coke to the metal instead of adding carbon in the form of pig iron. If pig iron is added, it is preferably in the molten condition. The metal thus enriched in carbon is then charged into an electric furnace where it is treated with basic additions for removal of sulphur and phosphorus, and for increase of its heat to bring it into refined and heated condition proper for casting into the ingot molds.

The importance of adding carbon to the blown metal before introducing it into the electric furnace is that in this way the loss by skulking is lessened, and by bringing the metal to a definite carbon content the heats in the electric furnace are made uniform in character and duration, the product rendered

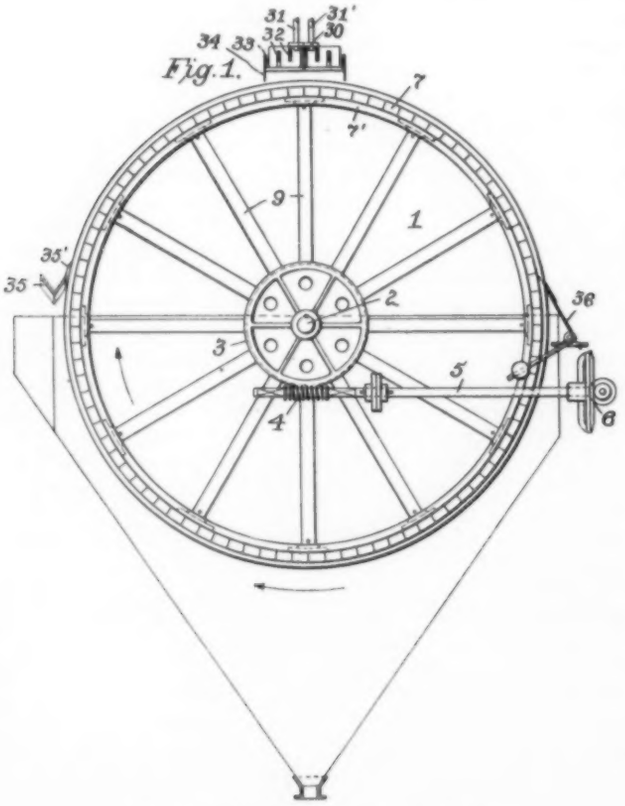


FIG. 1.—ROTARY FILTER FOR ORE SLIME

more uniform and the manufacture thereby greatly facilitated.

As the decarbonized metal is low in carbon when taken from the converter and is often transferred a considerable distance to the electric furnace, a considerable amount of this metal will solidify in the ladle and form skulls therein. This skulling action will reduce the amount of metal poured into the electric furnace from the ladle, and as the skulling action will vary, the amount poured in will vary. By adding carbon to the metal before its being carried to the electric furnace, its carbon content is raised and its melting point thus lowered, and the amount of skulling during the transfer to the electric furnace is prevented or greatly lessened. This, therefore, makes the charges more uniform in amount as poured into the electric furnace. The obtaining of a uniform carbon content is rendered easy by adding carbon to the blown metal rather than by attempting to stop the blow at the desired point, for to determine the point of stopping before the flame drops is very difficult, while to add the necessary percentage of carbon to the bath depleted of carbon is easy. (13,538, February 25, 1913.)

Methods of Handling Slag.—The production of blast or open-hearth furnace slag in a granular condition, and the efficient handling of such product, form the basis of a patent granted to Mr. David T. Croxton, of Cleveland, Ohio. The inventor provides shallow pits near the furnace, of such capacity as to hold the slag produced in 24 hours. Arranged on the bottom of the pit is a parallel series of flexible members, such as chains, attached to pins at each side of the pit. The slag is allowed to run uniformly over the pit, each successive charge of slag forming a layer over the previous one. When the pit is full, each chain is successively detached from one of its retaining pins, and lifted or ripped upward through the bed of slag. The latter is disintegrated and then removed from the pit by a grab bucket or other suitable device. Slag produced by this method is claimed to be in good condition for use as road ballast or an aggregate for concrete. (1,056,632, March 18, 1913.)

Another invention having a similar object in view is that of Mr. George L. Danforth, Jr., of Chicago, Ill. He provides a slag receptacle consisting of a long metal trough, having a slot-like opening running lengthwise along the curved bottom. This slot is normally closed by strips of metal, designated agitators, attached to vertical arms by means of which they may be raised or lowered. Slag is run into the receptacle, forming a layer, which is then sprayed with water to cause shrinkage and cracking. When the first layer is cool another charge is run on, and this action continued until the receptacle is full. The agitators are then lifted by a crane, disintegrating the slag, and allowing it to run out through the slot in the bottom of the receptacle. (1,058,158, April 8, 1913.)

Manganese Steel.—Mr. Albert E. Greene, of Chicago, Ill. produces manganese steel or other alloy steels by charging the solid ferro-manganese into a suitable vessel, then pouring enough molten soft steel of proper composition on top of it and completing the melting and heating in a reducing atmosphere by means of electric heating. (1,060,078, April 29, 1913.)

Steel for Electrical Purposes.—Sir Robert A. Hadfield, of Sheffield, England, the well known pioneer in the manufacture of alloy steels, has covered in an older U. S. patent 745,829 of Dec. 1, 1903, the heat treatment of an iron-silicon alloy for the purpose of obtaining a magnetic material of high permeability, high electric resistance and low hysteresis. He now claims a process of making this alloy of improved solidity and homogeneity of structure. It will be especially adapted for use in ballast coils, transformer plates and like electrical apparatus, wherein the total magnetic and electric losses have to be reduced to the lowest possible degree. The essential feature of the process is that 50 per cent ferro-silicon is placed in a ladle or other vessel and raised to a red heat. The pure molten iron is poured upon the red-hot ferro-silicon and fuses the same. Inasmuch as the latter substance fuses about 300 deg. to 400 deg. C. below the iron, the additional heat units required to dissolve the silicon-alloy are small and readily communicated to it from the iron itself. Just before casting in ingots a suitable proportion of alumnium, not exceeding 1 per cent, or other equivalent deoxidizer, is added to the mixture. (1,061,373, May 13, 1913.)

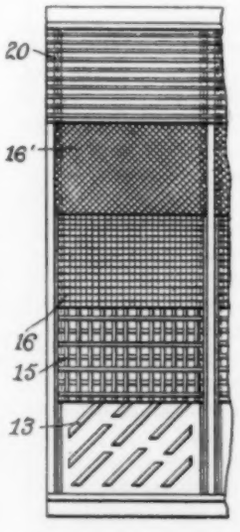


FIG. 2.—DETAIL OF FILTER SECTION

Charging Apparatus for Blast Furnaces.—Messrs. E. J. Windsor-Richards and T. Lewis, of Glengarnock, Scotland, patent charging apparatus of the hopper type and inclined railway for charging buckets. Characteristic features are the small amount of headgear and parts projecting from the top of the furnace foot plate. (1,061,349, May 13, 1913.)

Gold and Silver

Rotary-Drum Vacuum Filter.—Figs. 1, 2, 3 and 4, show details of a revoluble filter for use in the cyanidation of gold ores, designed by Mr. RANDALL P. AKINS, of Denver, Colo., and assigned by him to the Colorado Iron Works Co., of the same place. Fig. 1 gives a side view, showing a drum 1

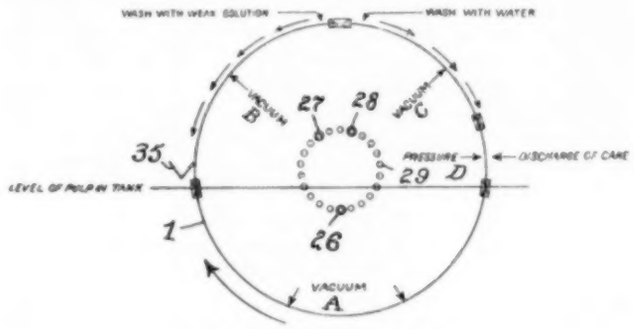


FIG. 3.—CYCLE OF FILTRATION

mounted on an axle 2 which is driven by a worm wheel 3 and worm 4. The face of the drum is composed of filter sections, as shown in Fig. 2, wherein 13 indicates strips of wood fixed to the face of the drum, supporting coarse wire screen 15, on which are placed successive layers of burlap 16 and canvas 16'. Outside of these layers of filtering material is wound a series of wires 20 to hold the filtering medium in place. Each of the filter sections has separate pipe connections to the valve in the hub of the drum.

The valve is designed to permit the separate withdrawal of gold and wash solutions, and to conduct compressed air to one section at a time for the purpose of dislodging the cake from the filter. The cycle of the various steps is shown in Fig. 3. That portion of the filter below the line of pulp in the tank is under vacuum, which results in the withdrawal of valuable solution and the formation of a slime cake on the surface of the filter. As the drum revolves, the rising side is washed or sprayed with weak cyanide solution from a box or pipe placed at the top of the filter, as shown in Fig. 1. This wash solution is removed by vacuum and delivered separately from the first solution. A similar wash, with a separate removal, can be applied from the box or pipe to the face of the filter as it travels downward into the tank again.

The controlling valve situated at one end of the hub consists of a movable plate and a stationary plate or member. The former is attached to the drum and has a circular line of openings connecting with the pipes leading to each separate

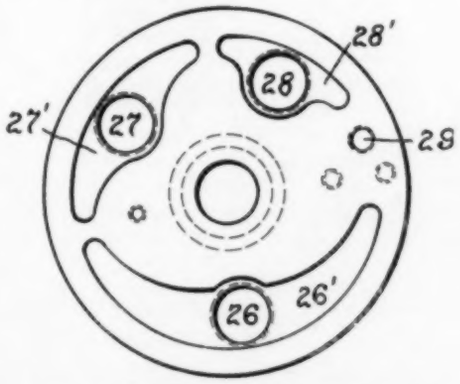


FIG. 4—STATIONARY MEMBER OF FILTER VALVE

section of the filter. The stationary member of the valve, shown in Fig. 4, has three slots, 26', 27' and 28', and one circular opening 29. As the filter revolves, the openings in the movable member of the valve are continually registering with the different slots in the stationary member. Those registering with slot 26', as at 26, are under vacuum and are delivering gold solution to a suitable place; those registering with slots 27' and 28', as at 27 and 28, are also under vacuum and are removing the different wash solutions; while that opening in the movable member which registers with the opening 29 of the stationary member receives compressed air for the purpose of dislodging the cake on that particular section of the filter, after it has been washed. (1,059,327, April 15, 1913.)

Another form of filter, patented by Mr. HARRY E. KIER, of Colorado Springs, Colo., is shown in Fig. 5. It is designed for use in the cyanidation of gold and silver ores and is adapted to leaching and filtering. It consists of a tank with a spherical bottom of cellular construction, forming a filter. Within the tank is a revolving member composed of perforated pipes, having bearings outside the tank, and being driven by power applied to a pulley. Air can be delivered into the perforated pipes through a connection in the right-hand bearing and thus caused to mingle with the slime pulp in the tank.

In operation, slime pulp is delivered into the tank, aerated and kept in suspension until all valuable metal is dissolved. Filtration can proceed during this operation, the revolving arms

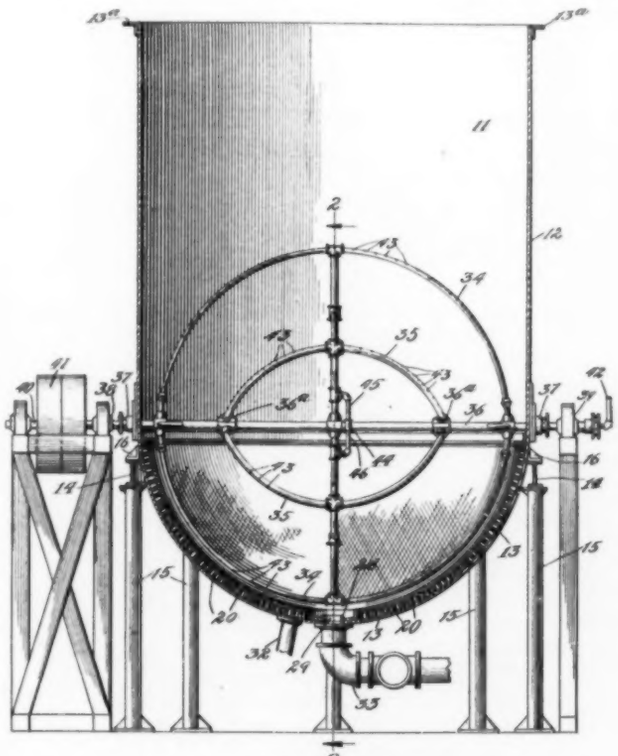


FIG. 5.—LEACHING FILTER TANK

keeping the filter surface free from impervious accumulations. The pulp can be washed with successive solutions and discharged through a pipe in the bottom of the tank. (1,058,869, April 15, 1913.)

Lead, Copper and Zinc

Production of Minium.—According to specifications of a patent recently granted to JAROSLAV MUHLBAUER, of Prague, Austria-Hungary, it is possible to greatly increase the rate of production of minium, Pb_3O_4, by carrying on the customary process of oxidation under a pressure of several atmospheres instead of at ordinary pressure. Minium is ordinarily produced by roasting oxide or carbonate of lead. The process is slow and the material must be roasted in thin even layers for periods ranging from 24 to 48 hours. The reaction cannot be accelerated by increasing the temperature, but the inventor has found that by increasing the pressure under which the oxidation takes place, say to 12 atmospheres, he can accomplish within one hour the same effect produced at ordinary pressure in 15 hours. By using pure oxygen under pressure the reaction occurs in a few minutes. (1,050,195, April 15, 1913.)

Extracting Tin from Base Bullion.—An improved process for removing tin from lead or base bullion is due to Brian C. Besley, of Howell, N. S. W., Australia. A reverberatory furnace is charged with a certain quantity of rock salt. When the salt is molten, lead or base bullion is introduced, sinking beneath the salt cover. Oxide of lead, preferably litharge, is then added to the bath, in the ratio of two parts litharge to each part of tin in the bullion. After about half an hour

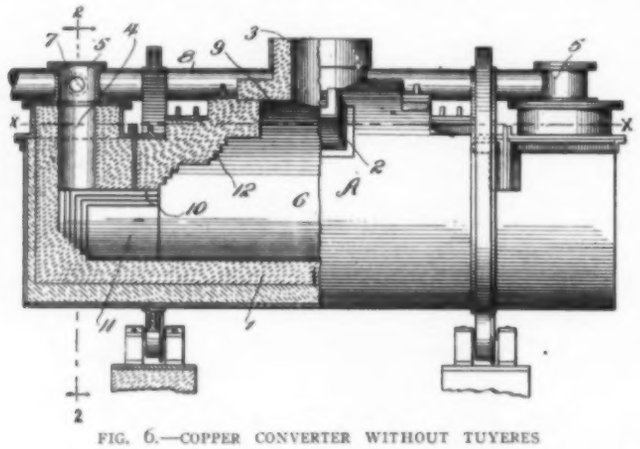


FIG. 6.—COPPER CONVERTER WITHOUT TUYERES

all the tin has become associated with the litharge, whereupon the refined bullion is run out of the furnace, followed by the salt, leaving the solid tin-lead oxide combination to be removed in lumps. The latter is then smelted for the recovery of a marketable tin-lead solder. The salt can be used repeatedly. (1,060,527, April 29, 1913.)

Copper Converter Without Tuyeres.—In Fig. 6 is shown an elevation, partly in section, of a form of copper converter patented by Mr. Howard B. Jernee, of Perth Amboy, N. J. The principal object sought in this type of construction is the elimination of the tuyeres of the ordinary type and the troubles incident to their use. As seen in Fig. 6, the converter consists of a cylindrical body A, rotatably mounted, and having an opening 3 for the reception of ore and discharge of gases. Air boxes 5 are placed at each end of the shell, and are connected with an air pipe 8. Air inlets extend downward from the boxes into the ends of the converter, as at 4. The body of the converter is lined with refractory basic material 1, which is so arranged that the inner chamber is contracted at the ends. The bottom surfaces 10 of the outer ends of the top wall of the lining 1 are preferably straight or flat, and extend well down toward the bottom wall of the lining, forming baffles 12, which serve as deflecting surfaces to increase the efficiency of the air.

In operation, the converter chamber is filled with matte, and air is forced through the passages 4, flowing through the body of the metal and finally escaping through the opening 3. (1,059,367, April 22, 1913.)

Electrodeposition and Refining of Zinc.—A method of electrolyzing a strongly acid solution of a zinc salt with a current of high density is patented by Urlyn C. Tainton, of Manchester, and John N. Pring, of Sandbach, England. The inventors prefer a sulphate solution of zinc, with from 10 per cent. to 30 per cent. of sulphuric acid, and 0.1 per cent. to 1 per cent. gum tragacanth. This is electrolyzed with a current density of 500 amperes per sq. ft. of cathode surface. Densities of 1/5 this amount can be used with success, but time is saved by the higher density.

The novel features of the process are: the high current density employed, the production of a smooth, lustrous and compact deposit, the use of a colloid agent, such as gum tragacanth, the wide limits of acidity, and its adaptability to plating on aluminium. The method is specially useful in galvanizing wire electrically. (1,059,233, April 15, 1913.)

Reduction of Zinc Oxide.—The usual practice in zinc smelting consists in making an intimate mixture of some form of zinc oxide and carbon, and subjecting this mixture to a high temperature in small retorts. The method is wasteful of heat, does not effect complete reduction of the zinc, and entails considerable expense for retorts. A general feature of all proposals for zinc smelting, is the intimate mixture of the ore and reducing agent. In contrast to this feature is the proposal of Prof. Charles F. Burgess, of Madison, Wis., whose process consists in keeping the zinc ore and carbon entirely separate from each other. In the preferred form of his process, the zinc ore is heated electrically, and the zinc oxide thereby volatilized. Simultaneously a mass of carbon is subjected to a current of electricity to heat it to a proper reducing temperature. The vapors of zinc oxide are then passed through the mass of incandescent carbon, and the reducing action is quickly and thoroughly accomplished.

A form of furnace in which the operation can be carried out is shown in Fig. 7. The zinc vaporizing chamber is shown at *A*, and the carbon container at *B*. Electrodes 4 in the ore chamber provide the necessary heat for volatilization of zinc oxide, and electrodes 9 and 11 in the carbon chamber are used to bring that body to the proper temperature. A passage 8 provides an exit for the volatilized oxide into the reducing chamber. Slag may be removed from the ore chamber by the tap 7; ashes can be removed from the carbon chamber through the door 18. Flues 16 and 17 provide for the exit of the reduced zinc vapor. The consumption of carbon in this form of furnace is very limited, as it is confined practically to that required in the reduction of ZnO to Zn.

The advantage of this kind of a furnace is very considerable, inasmuch as the temperatures for volatilization of zinc oxide and its reduction to zinc are not the same, the proper temperature for the carbon being considerably lower than that which is required to volatilize the oxide. Mr. Burgess has found by experiment that zinc oxide begins to volatilize from ore at a temperature of about 1100 deg. C. This, therefore, is the minimum temperature at which the ore chamber should be maintained. By heating at a higher temperature, the action is carried on more rapidly, but with volatilization of impurities

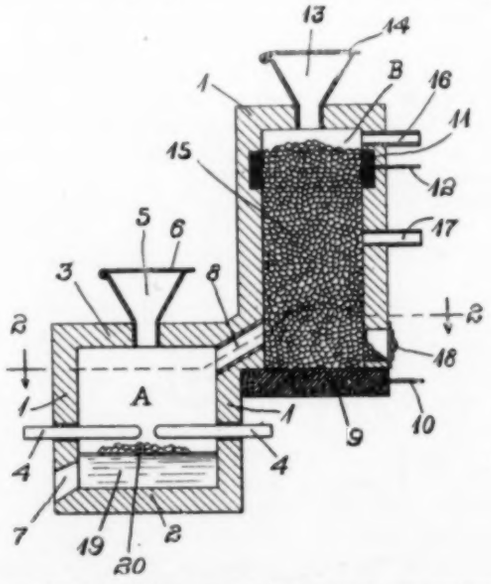


FIG. 7.—ELECTRIC FURNACE FOR VOLATILIZATION AND REDUCTION OF ZINC OXIDE

which are undesirable. Experiment has shown that zinc oxide can be completely volatilized from ordinary roasted zinc ore by the method just described. (1,059,342, April 22, 1913.)

Roasting Furnaces

Construction of Multiple Hearth Furnaces.—In a patent recently granted to Reinhold Scherfenberg, of Berlin, Germany, the inventor presents certain improvements in furnaces of the McDougall type. In ordinary construction, the passages

for the downward movement of roasted ore are used also for the upward passage of air from one hearth to the next. In the present case, the inventor introduces air free from SO_2 to the several hearths through the central tube of the furnace, and separate conduits distributed at the circumference of each hearth to convey the gases enriched with SO_2 directly to the uppermost hearth. Means are provided for regulating the passage of the air and gases. (1,057,584, April 1, 1913.)

Another patent of similar intent is that granted to MR. UTLEY WEDGE, of Ardmore, Pa. His improvement consists in placing flue casings in the side walls of the furnace, to divert the draft from the passages for the downward flow of ore. The casings extend through the wall, so as to be accessible from the outside. (1,060,389, April 29, 1913.)

Dust Collection and Filtration

A dust collector suitable for use in sulphuric acid work, for the separation of dust from the gases coming from the roasters, is shown in Fig. 8. It is the invention of Mr. WILLIAM T. HARDER, of South Baltimore, Md. It consists of a series of frames containing a large number of shelves, placed in the flues leading from the roasters. The normal position of the shelves in the flue is horizontal, in which position they gather the dust from the gases passing between them. The frames are adapted to be rotated, so that their load of dust can be dumped into suitable hoppers in the bottom of the flue. In the figure, one of the frames is shown partly rotated to the dumping position, and one in the dumping position. At the

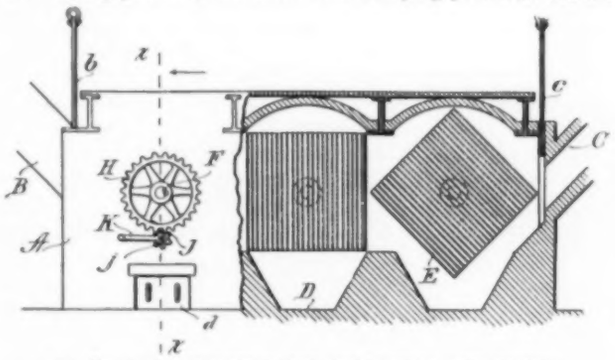


FIG. 8.—DUST COLLECTOR FOR SULPHURIC ACID WORKS

left is shown the mechanism for changing the position of the shelves. It is understood that the flues are in duplicate, so that one can be closed while dumping the shelves in the other.

A filter medium suitable for use in filtering acid gases coming from smelting or roasting furnaces, has been patented by Dr. FREDERICK G. COTTRELL, of Berkeley, Cal. Dr. Cottrell has found that the deterioration of cotton and other vegetable fibers in acid gases is due chiefly to the esterification and hydrolysis of the cellulose which is itself conditioned by the carbohydrate grouping of that body. By breaking down the groups of cellulose without seriously disturbing the mechanical strength of the fibers, a fabric can be obtained which has great resistance to the action of acids. This breaking down of the cellulose groups can be accomplished by heating the fabric, preferably out of contact with air, at a temperature above 200 deg. C.

As an example of the results obtained by this treatment, the following is cited: Cotton fabric weighing 350 g. per square meter and having a tensile strength of 2300 kilos per meter, were heated in a closed vessel to maximum temperatures of 300 to 340 deg. C., for periods ranging from 10 minutes to 3 hours. After cooling in the closed vessel they were found to be perfectly flexible and of a uniform dark brown to jet black color. The samples lost from 68 per cent to 76 per cent of their weight, and showed a tensile strength of 30 to 85 kilos per square meter. They withstood boiling in sulphuric acid without imparting any color to the latter. The inventor prefers to use this fabric in the form of bags, as for bag houses, and to treat the bags after they have been made. After the heat treatment the fabric will no longer burn with a flame. (1,060,065, April 29, 1913.)

Electric Furnace Processes

Regulating electric furnaces.—Most of the regulators for arc furnaces, based on the application of an auxiliary current to raise and lower the electrodes, suffer from the inconvenience that the regulator cannot be stopped at exactly the desired posi-

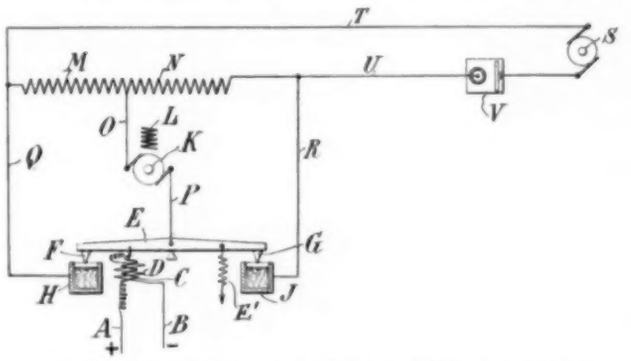


FIG. 9.—CONNECTIONS OF ELECTRIC FURNACE REGULATOR

tion. The momentum of the moving parts causes them to move too far until the opposite regulation takes place, thus resulting in a continual swinging of the parts, back and forth past the point of perfect regulation. A new invention of Dr. PAUL L. T. HÉROULT, of La Prar, France, overcomes this difficulty by an additional device inserted into the auxiliary circuit and allowing to break same a sufficient length of time—which can be regulated—in such a way that the regulation of the furnace is effected step by step and to enable the new position of the furnace to have its effect upon the regulating apparatus.

Fig. 9 is a diagrammatic view of the electrical connections. *A* and *B* represent the furnace circuit, *C* a movable, *D* a fixed coil. *C* is mechanically connected to the lever *E*, the ends of which *F* and *G* can dip into mercury cups *H* or *T*. *K* is the motor which actually moves the regulable parts of the furnace. *M*, *N*, are the two parts of its armature resistance. The current generated in *S* passes through *M* or *N* according to the position of the lever. So far the arrangement has been known before and its working does not need to be explained. The special feature of the invention is the apparatus *V*, of Fig. 1, inserted in the current leads *T* or *U* at any point common to both the forward and the backward regulating currents. It is especially illustrated in Fig. 10. A ring of copper or other con-

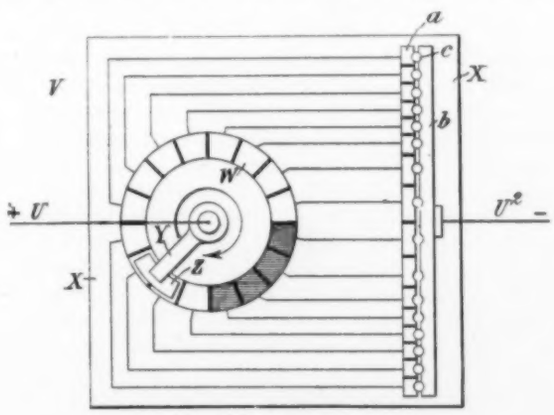


FIG. 10.—DETAILS OF REGULATOR

tacting segments *W*, insulated from each other is mounted on an insulating plate *X*; a rotating arm *Y*, carries a brush *Z* which passes over the segments *W*. *Y* is connected to one branch U^1 of the circuit direct, the segments are connected to the other branch U^2 individually over contact blocks *a*, plugs *c* and conducting bar *b*. The entire device is connected to a small motor *l* (Fig. 11). The speed of this motor rotating the

arm *Y* and the number of segments plugged can be variated and so adjusted as to allow the most efficient furnace regulation. Fig. 11, showing an assembled design without the auxiliary wiring is self-explanatory. (1,061,612, May 13, 1913.)

Manufacture of Silicon.—Messrs. Thomas B. Allen and Frank J. Tone, of Niagara Falls, N. Y., assignors to the Carborundum Company, have greatly improved the efficiency of the arc furnaces previously described by Mr. Tone in U. S. P., 921,183 of May 11, 1909, for the production of silicon. As the larger volume of carbon monoxide gas escapes along the electrodes carrying with it the vapors of silicon and its oxides, the

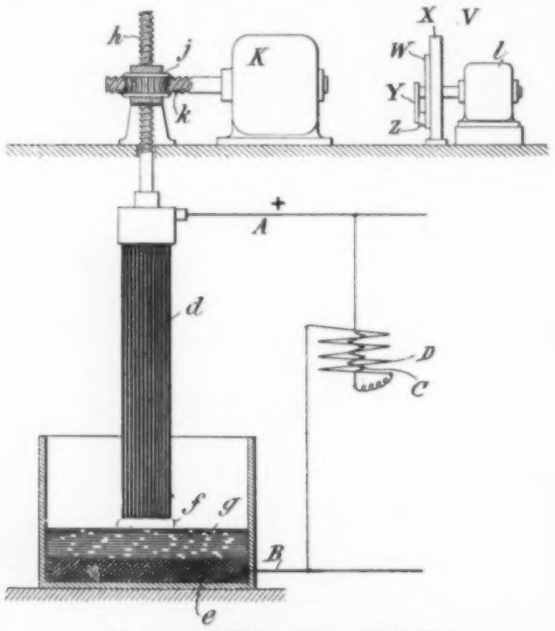


FIG. 11.—ELECTRODE WITH REGULATOR

furnace mixture is finely divided, for example, 12 mesh and finer, and formed into briquets of preferably spherical shape. The interstices then are so evenly distributed over the furnace section that the silicious vapors are condensed all over in the cooler parts of the charge and the carbon monoxide gas being discharged quite uniformly throughout the entire mass preheats the charge more efficiently. The briquets are made from 70 parts pure silica, 30 parts of petroleum coke mixed with 7 per cent hard pitch; 1½ in. has been found to be the best diameter. (1,061,256, of May 13, 1913.)

Electrolytic Processes

Manufacture of Persulphates.—It is generally known that the direct electrolysis of potassium-sulphate produces persulphate only with very poor yields and that therefore mostly ammonium-persulphate is produced from the sulphate by electrolysis in cooled acid solutions and reacted on by potassium-carbonate. From the resulting ammonium-carbonate the sulphate must be regenerated by the aid of sulphuric acid. Messrs. G. Adolph and A. Pietsch, of München, Germany, succeeded in finding a process of producing potassium-persulphate directly from the sulphates, the neutral as well as the bisulphate by acting with the solid salts on the solution of ammonium persulphate. The ammonium sulphate thus obtained can be regenerated into persulphate by electrolysis. The expensive potassium carbonate and the addition of sulphuric acid for conversion of ammonium carbonate are thereby entirely eliminated. In going one step further the inventors have found that the potassium salts in solid form can be added to the ammonium sulphate in the electrolytic cell direct and the electrolysis carried on with a yield of from 80 per cent at the anode while the reduction does not exceed more than 1 to 2 per cent, no diaphragm being required. The sodium persulphate which on account of its great solubility, hitherto was very difficult to obtain, can be prepared with great ease by the analogous process, a diaphragm, however, being employed in view of the ready solubility of the sodium-persulphate. (1,059,809, of April 22, 1913.)

Electrodeposition of Nickel, Iron, Cobalt.—Mr. Charles J. Reed, of San Francisco, Cal., claims an improvement in the electrodeposition of highly magnetic metals, like nickel, iron and cobalt from sulphate solutions with an insoluble anode. He refers to Carl Hering who overcame the difficulty in the case of zinc. Iron has the same property as zinc that it is not easily or efficiently deposited in the presence of free sulphuric acid. It is further unreduced and unaffected in solution as sulphate by contact with metallic lead. The invention consists in electrolyzing the iron sulphate solution with a cathode of any suitable conducting substance, such as carbon, copper, aluminium, etc. As anode is chosen spongy or finally divided lead such as is usually employed in the negative plates of a storage battery. When electrolyzing, the chemical reactions taking place may be represented by the equation: $Pb + FeSO_4 = Fe + PbSO_4$. After precipitating the iron, the anode is removed, placed in a dilute solution of sulphuric acid, and reduced by the electric current to metallic spongy lead. It is then ready for another use. (1,055,652, March 11, 1913.)

The same process applied to cobalt instead of iron is covered by Mr. Reed's patent 1,055,653, March 11, 1913.

Process of Manufacturing Plated Goods.—Mr. David G. Rea, of Providence, R. I., makes a two-fold application of electrolysis in the process of protecting the surface of precious metal, during the act of forming an article from this metal. The various parts necessary for the construction of the article, are first shaped in the rough, then electroplated with a base metal, preferably nickel. The parts are then trimmed and assembled, soldered, or otherwise fitted together. Hereafter the base metal is removed or stripped from the surface of the precious metal, by subjecting the completed article to an electrobath. The surface of the precious metal is thus maintained in perfect condition. (1,060,361, April 29, 1913.)

Synopsis of Recent Chemical and Metallurgical Literature

Gold and Silver.

Mexican Cyanide Practice.—The new 250-ton mill of the Cia. Beneficiadora de Pozos, at Pozos, Guanajuato, Mexico, is described by H. F. Carter in the *Informes y Memorias* of the Mexican Institute of Mining & Metallurgy, Vol. 3, No. 2. Certain machinery existing at another mill had to be used in the Pozos mill, which otherwise would not have been selected. Symons gyratory crusher and Symons disc crushers are in use, and have given excellent results. The latter are used to reduce the ore to ½-in. size, and have shown a capacity of 250 tons each in 12 hours, with an expenditure of 28 hp. The crushed ore is sampled in a series of two Snyder disc samplers, delivering an ultimate sample of 1 per cent of the mill feed. Chilean mills are used following the Symons disc machines. They have runners of 7 ft. 2 in. diameter and 19 in. face. Each runner is fitted with a tappet arm terminating in a 5-in. roller which strikes an adjustable inclined frame on the operating lever of the feeder. A further adjustment of the feed is obtained by means of a turnbuckle on the feeder mechanism, and the whole arrangement works exceedingly well. Rakes carried by the cross heads direct the ore under the runners and also swirl it against the screens.

Dorr classifiers are used to separate sand for tube milling. Two of the tube mills have El Oro liners, and two have Komata liners which have been used so successfully in New Zealand. The latter consist of longitudinal angle-bars or ribs about 18 in. apart with plates between. The bars lift the pebbles to the proper height without any slip. It is claimed for the Komata liner that it gives increased capacity; perfect cascading of pebbles on the lining; small consumption of pebbles, power and metal; and that it can cast locally of semi-steel, white or grey iron, and is easily installed.

Close concentration is not desired, as it is necessary only to-

remove ingredients which are noxious to cyanidation. Deister sand tables are used, with the shortest possible stroke, at 275 r.p.m. The slime pulp from the tables is thickened in Dorr thickeners to 1.5 to 1, elevated by Frenier pumps working in tandem, each with a 15-ft. lift, to Pachuca tanks. There are six of the latter, arranged in a circle and adapted for continuous agitation. Each has an overflow discharge pipe, so that any one tank may be the receiver, and any one can be cut out for repair. The 4½-in. connecting pipes between the tanks are inclined at 60 deg., and the upper end is provided with a valve or cover, readily removable. When it is desired to cut out a tank, the pipe cover is placed on the pipe of the tank preceding it, as is also done in the case of the last tank in the cycle. The overflow pipe of this tank is left open while those of all the others are plugged. The overflow is received in a box, and thence flows to an intermediate tank outside the filter house. The Pachuca tanks are connected at the top by launders, and three of these have shoots inclined downwards to carry off scum which is sometimes troublesome.

The Moore system of slime filtration is used, and the gold solution is precipitated on zinc shavings. Melting of precipitate is done in a Steele-Harvey tilting crucible furnace. Electric power is used throughout, and the mill is effectively lighted by 100 32-cp tungsten lamps.

Errors in Sampling and Assaying Ores Containing Coarse Gold.—A discrepancy between the quantity of gold recovered and that which apparently should have been found in the cyanidation of a low-grade ore, caused Mr. FRANKLIN WHITE to investigate all possible sources of error in estimating the value of the ore treated and the residues discharged. Some of the results of his investigations, particularly on assaying, are contributed in *Bulletin* No. 103, Inst. Min. & Met.

It had been the custom to make three assays of 3 A.T. each, and weigh the combined buttons. On investigation it was found that the individual buttons did not check, and that the combined weight did not give an average result that could be relied upon. Variations of from 10 per cent to 30 per cent were noted in a long series of assays:

Examination of the ore showed that the gold existed chiefly in a finely divided condition, but that occasionally it occurred as flake or leaf gold, and on rare occasions, as very coarse gold in quartz. In crushing, the fine portion of the ore was always richer. Sampling and assaying, therefore, were difficult, and the errors finally were ascribed to the accidental presence of particles of coarse gold in the samples. Trials were then made to ascertain the best way of obtaining samples. The old coning and quartering method of sampling, as well as others, was subjected to critical tests, but without satisfactory results.

In order to show the effect of uneven distribution of large particles of gold in the ore, some ingenious tests were made, using ore containing small colored beads and lead shot, to which arbitrary values were assigned. Samples of this kind were quartered, and the number of beads and shot in each sample counted. The greatest variation imaginable occurred, and there was no uniformity in the number of beads appearing in the different samples at successive steps in the process.

The investigations were continued on typical ore samples, which were quartered carefully, and the final sixteen products of the fourth subdivision were assayed. From the results obtained, it appeared to the author that when coarse gold is unevenly distributed in an ore, the odds are against obtaining a correct sample by any means. Neither is it probable that the average of the assays of the whole final quartering will be correct. The probabilities are in favor of the average being too high rather than too low, as the smaller and more evenly distributed particles of gold will be in much the same numbers in every case, whereas the larger pieces, less in number, will be distributed more irregularly.

The author is further of the opinion that fine grinding of the sample is not an adequate remedy, for this would simply result in evenly distributing the few coarse particles of gold throughout the mass, and while the results would be more even, they would still be too high.

The conclusion arrived at is that assays should be made in triplicate, and that repeats should be made in the case of notable variations. The abnormally high results should be rejected and not included in the average result.

The San Francisco Mill, Pachuca, Mexico.—This mill was the first to use the cyanide process in Pachuca, and was also the pioneer in the use of the Brown agitating tank, otherwise known as the Pachuca tank. The present practice is described by J. P. HOLCOMBE, in *Bulletin* No. 103, Inst. Min. & Met. The ore contains principally sulphide of silver, with some manganese, galena, pyrite and blende. The latter three minerals are removed by coarse concentration. The average value of the mill feed is about 20 oz. silver and 0.10 oz. gold per ton. The crushing machines are Blake crushers, Cornish rolls and stamps. The ore is stamped in cyanide solution through screens having six or eight holes per linear inch. The first operation is concentration on Wilfley, whereby about 14 per cent of the valuable mineral is removed. The tailings are classified and reground in tube mills.

The stamps have a much greater capacity than the tubes, hence the small duty of the former, 5.57 metric tons in 24 hours. The tube mill feed is kept as thick as possible and contains about 35 per cent moisture. All the tubes have El Oro linings. Mine rock is used instead of imported flint pebbles, and has been found quite as effective. The consumption is 67.5 lb. per ton of ore. This rock contains approximately 6.43 oz. silver per ton.

The classifier overflow, containing 8 parts solution to 1 of ore, is thickened to a consistency of 1.2 to 1, and agitated in Pachuca tanks where sodium cyanide is added to bring up the strength of solution to 0.4 per cent KCN. Cyanide consumption is 1.83 lb. KCN per ton of ore. Protective alkalinity is kept at 2 lb. CaO by adding lime at the tube mill. Lime consumption is 9.7 lb. per metric ton. Agitation is continued for 36 hours, following which there is a rest of 10 to 12 hours and then further agitation before filtering.

A Moore filter of forty leaves treats 220 tons of ore per 24 hours, with the following cycle: Loading, 20 minutes; barren solution wash, 40 minutes; water wash, 15 minutes. The cake is 1¼ in. thick. Precipitation is done in boxes, and the precipitate is washed through a 40-mesh screen and pumped into a Shriver press. No acid treatment is given. Oil furnaces are used for melting, consuming about 0.328 gal. of oil per kilo of bullion. The flux is 7 per cent borax glass, 5 per cent soda ash, 1 per cent lime and 2 per cent sand. The bullion assays from 910 to 940 fine in silver, with four to five parts gold.

The average cost per metric ton milled is as follows:

Rock breakers	$0.11
Batteries	0.24
Concentration	0.04
Tube mills and classifiers	0.29
Agitation	1.05
Filtration	0.16
Pumping	0.09
Precipitation and melting	0.41
Sampling and assaying	0.13
Surface expenses	0.05
General repairs	0.17
Power	0.81
General expenses	0.31
	$3.86

The extraction during the period to which the above costs apply was 92.4 per cent of the silver and 94.5 per cent of the gold.

Slime Settlement

A series of interesting experiments on slime settlement is recorded by Mr. W. SHELLSHEAR, in the *Proceedings* of the Australasian Inst. Min. Eng., Dec., 1912. The author used various minerals which were selected for their purity. The list includes zinc blende, galena, rhodonite, garnet, felspar, quartz, calcite, iron pyrite, copper pyrite, bornite, magnetite,

wolframite, scheelite, tin oxide, fluorspar, mica schist, steatite, kaolin, stibnite and molybdenite.

Each mineral was crushed extremely fine in an agate mortar. Distilled water was used to make the suspensions, and some reagents were added to determine their effect on the rate of settlement. An examination of the settling rates of the different minerals showed that they could be divided into three classes, according to the time required for the settlement. Those requiring from 7 to 8 hours to one week were classified as slow settling; those settling in 4 to 7 hours, intermediate settling; and those requiring only 1½ to 3 hours, fast settling. In all cases 2 g. of mineral were suspended in 100 cc. distilled water, and allowed to settle until the water was clear.

Class A, Slow		Class B, Intermediate		Class C, Fast	
Tin oxide	4 -7 da.	Copper pyrite	4-5 hr.	Zinc blende	3-4 hr.
Wolframite	4 -7 da.	Bornite	4-5 hr.	Calcite	2-3 hr.
Felspar	3 -4 da.	Molybdenite	4-5 hr.	Garnet	2-3 hr.
Steatite	20-30 hr.	Quartz	7-9 hr.	Iron pyrite	3-4 hr.
Kaolin				Magnetite	2-3 hr.
Mica Schist	30-50 hr.			Stibnite	3½ hr.
Rhodonite	2 -4 da.			Galena	3 hr.
Scheelite	3 -4 da.			Fluorspar	2-3 hr.

Investigation was made of the effect of different minerals on each other, with the following general deductions: Those of Class A have no effect on the settling of each other; those of Class B have no effect on the settling of each other; those of Class C will settle those of Class A if present in sufficient quantity; those of Class C increase the time of settlement of those of Class B; Class B will not settle Class A, but will either be held up or settle, leaving Class A in suspension.

It will be observed in the table that the sulphides are in Classes B and C; also that three of the minerals of the slow-settling Class A are of high specific gravity, tin oxide, wolframite and scheelite. Again, calcite, a mineral of low specific gravity, is one of the most rapid-settling minerals in Class C. Curves are given which show that for mixtures of minerals of the different classes, there is a definite ratio at which the settlement is most rapid; also that the effect of dilution on settlement varies with the different classes. Thus, with Class A, the greater the dilution, the greater the settlement, as shown by tin oxide. With Classes B and C, and with mixtures of C and A (provided the Class A mineral is not present in sufficient excess to change the mixture into a slow-settling one), the dilution does not affect the rate of settlement.

In testing the action of electrolytes, the author found that 2 cc. of N/10 sulphuric acid per 100 cc. water hastened the settlement in all classes. Calcium chloride has a similar effect, but is specially rapid on suspensions of silicious matter. Lime has an action similar to that of calcium chloride. Caustic soda in small quantities (1cc. N/10 solution per 100 cc. water) causes silicious slime to remain in suspension; in large quantities, however, t acts similarly to the electrolytes. Alum and sodium carbonate settle all classes of slime by forming precipitates. Potassium permanganate settles slime with great rapidity; while tannic acid kept all suspensions in a dense mass, depending on the strength of the solution. After continued agitation, however, the suspension suddenly settles rapidly.

Test for Gold in Precipitated Solutions.—The following test was devised by Mr. Dowsett, reduction officer at the Brakpan mill, South Africa, for use in connection with the Merrill system of zinc-dust precipitation. To 1000 c.c. of cyanide solution add three drops saturated solution of lead acetate and shake. Add 0.75 g. zinc-dust and shake again. Add 20 c.c. saturated cyanide solution and shake for 30 seconds. Pour into an evaporating dish and allow to settle. Pour off solution and dissolve zinc-dust with 10 c.c. aqua regia, boiling until the solution is reduced to about 4 c.c. Decant the solution from the chloride of lead and pour a few drops into a test tube. Cool and add two drops of tin chloride solution. If gold is present to the extent of 0.02 dwt. per ton of the original cyanide solution a very slight coloration will be observed; 0.03 dwt. will show a slight yellow; 0.04 slight pinkish-yellow; 0.06 strong pink, and 0.08 purple of Cassius. The test can be made in a few minutes, and indicates the efficiency of precipitation.

Refractories Manufacturers' Association

Closely following steps taken a number of years ago by industrial and manufacturing interests of all types in this country, about forty of the leading manufacturers of refractories in the central, western, and eastern states have perfected an organization known as the Refractories Manufacturers' Association. The last steps toward organizing the new association were taken at a meeting held April 22, at the Fort Pitt Hotel, Pittsburgh, which was attended by about two score of the most prominent officials connected with the refractories trade.

Manufacturers of refractory products have long since felt the need of an organization that would bring them into closer personal and social relation with their competitors. Although such an organization had been discussed for a number of years, the project remained in an embryonic state until the early part of the present year, when renewed interest was taken in the movement.

The new organization is similar in many ways to those maintained by other business interests throughout the United States. At the April 22 meeting, a constitution was drawn up and accepted, and officers were elected. Any individual or company, engaged in the manufacture of refractories, is eligible to membership and it is probable that the membership roll eventually will contain the names of every prominent official identified with the trade.

The purpose of the organization is "to promote closer relations between manufacturers, dealers and consumers of all kinds of refractories; to improve the products of its members; to standardize, as far as possible, the various designs and shapes of products manufactured; to endeavor to secure the most equitable freight rates for manufacturers and consumers; and to promote social intercourse among its members." It is the intention of the organization to secure some of the most prominent ceramic experts, engineers, and manufacturers in the country to make addresses at the regular meetings.

Mr. H. D. Savage, of the Ashland Fire Brick Company, Ashland, Ky., was elected president and Mr. John H. Cavender, of the American Refractories Company, Chicago, was elected secretary and treasurer of the Refractories Manufacturers' Association, and it is the ultimate intention of the Association to have their own testing laboratory, etc.

The Executive Committee, composed of nine members, is as follows:

Missouri.—J. L. Green, Laclede-Christy Clay Products Company, St. Louis, Mo.

Illinois.—C. S Reed, Chicago Retort & Fire Brick Company, Chicago, Ill.

Kentucky.—E. S. Hitchens, General Refractories Company, Olive Hill, Ky.

Southern Ohio.—D. D. Davis, Davis Fire Brick Company, Oak Hill, Ohio.

Northern Ohio.—T. E. Thomas, Niles Fire Brick Company, Niles, Ohio.

Western Pennsylvania and West Virginia.—J. H. McFeely, McFeely Brick Company, Pittsburgh, Pa.

Central Pennsylvania.—Geo. H. Diack, Queens Run Fire Brick Company, Lock Haven, Pa.

Maryland.—C. H. Claiborne, Union Mining Company, Mt. Savage, Md.

New Jersey & New England.—Cyrus Borgner, Cyrus Borgner Company.

The members of the association will meet in Pittsburgh, May 20, at their next meeting and an interesting program is being arranged.

It is the general feeling of all parties concerned that the association cannot help but be of great benefit, both to the manufacturer and consumer, not only in such matters as the improvement of quality and character of products of its members, but also in working out and putting into effect efficient methods of manufacture, reduction of costs, standardization and all other problems of common interest to this important industry.

The Production of Sound Steel Ingots

Some seven years ago experiments were commenced by the Simonds Manufacturing Company, of Fitchburg, Mass., at their Chicago plant, aiming to develop a method for the production of sound ingots especially for the manufacture of saws, and the method and apparatus briefly described is the outcome of this long series of experiments. When it was first suggested that the ingots commonly used in crucible steel mills be made sound by fluid compression, it was felt that it would not be practical to develop a method and apparatus that would handle the very small ingots which it would be necessary to operate on, and it was found by investigation that practically no plants were in operation working on ingots of much less than a ton weight.

Having this in mind, the first experiments along the lines of method and pressing apparatus were on small experimental ingots weighing but 15 lb. each, and it was found that there was no difficulty whatever in producing these absolutely sound and without blowholes or pipes. The next step was on slightly heavier ingots, weighing around 110 lb., and of rectangular cross section 3½ in. x 5½ in. A pressing unit was then built capable of handling one 400-lb. ingot or two 200-lb. ingots at each heat and, with modifications from time to time, this arrangement has been found very satisfactory and at the present time at the steel plant of the Simonds Manufacturing Company, Lockport, N. Y., eight presses are in continuous operation, making ingots ranging from 180 lb. up to and including 600 lb. in weight.

It was found early in the series of experiments above referred to that it was quite out of the question to compress ingots in the same molds in which they had been poured, chiefly for the reason that the mold cost and up-keep was too great to make the proposition a commercial one. It was found that an ingot of approximately square cross section could be operated on more satisfactorily than any other cross section (excepting round or octagon), although ingots have been made

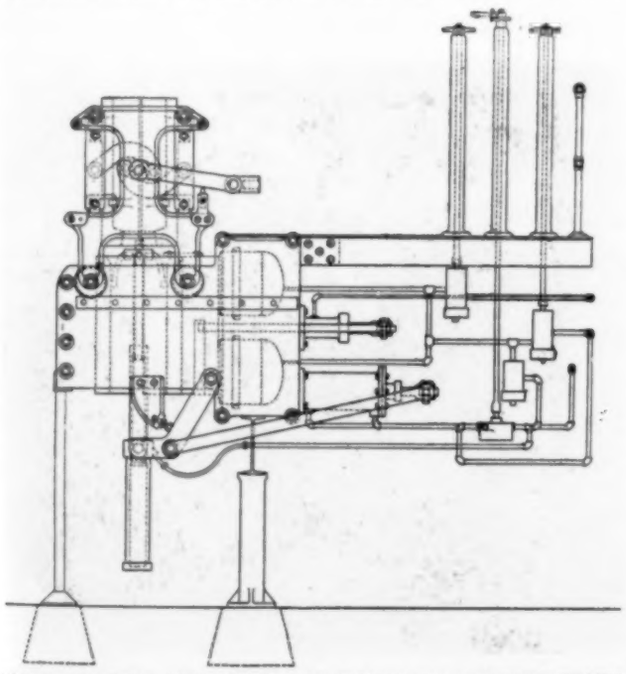


FIG. 1.—GENERAL ARRANGEMENT OF PRESSES FOR HANDLING INGOTS

satisfactorily by the process with a cross section 4 in. x 8 in. x 12 in., and weighing respectively 350 and 600 lb.

Another feature which our first investigations revealed was the fact that practically all attempts to compress ingots by lateral pressure previous to the method outlined here had been along the lines of placing a large number of molds "tandem" style in one pressing unit, and investigation as to the effect of this arrangement showed conclusively that there is practically only one ingot in the series that could possibly receive proper treatment. Aside from this, most of the apparatus of this nature was rather cumbersome and expensive to operate and the press had to be practically dismantled to get the ingots out after they had been operated on. It was, therefore, considered desirable to set to work on the lines of producing an apparatus possessing the following general features:

First, have the units small and extremely simple so that if

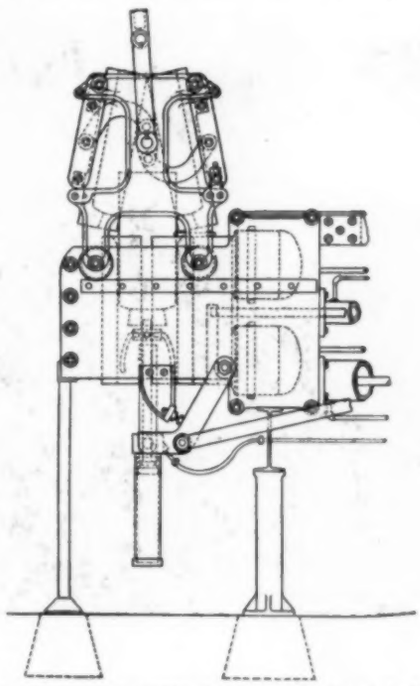


FIG. 2.—POSITION WITH INGOT PARTLY DESCENDED INTO THE DIES

one unit was out of order for any reason it would not in any way affect the rest of the plant.

Second, design these units so that the plant could be added to and the system extended at will and, at the same time, have each unit entirely separate and independent of the others so that it could readily be lifed out of its place with a crane if out of order or damaged and a spare unit put in its place. So far it has never been found necessary to do this, but it was considered desirable to have this in mind in developing this method.

Third, be able to operate on the ingots in such a way that every individual ingot receives precisely the amount of pressure and time necessary to get the best results without reference to any of the other ingots being cast at the same time.

Fourth, develop a mechanism that would be so extremely simple and rugged that it would not require a different type of labor to operate than is commonly found in melting shops.

In a general way, the method consists of casting the ingots in molds made of special cast iron and, while the ingots are still internally fluid but sufficiently set so that they will not burst by careful handling, they are transferred mechanically to steel compression dies where they receive lateral or "side" compression of from 1½ to 3 tons per square inch of greatest area of cross section operated on, this pressure depending largely on the composition of the steel, temperature of the steel when poured, etc.

Fig. 1 shows the general arrangement of presses for handling ingots up to 1½ or 2 tons and as small as may be desired, and as many of these presses as are necessary for a given output are arranged side by side, supported in any suitable way, dependent on local conditions. An extension of the back end of the press serves as a support for a working platform which is made continuous from press to press, this working platform on the smaller size presses being approximately 3 ft. wide and the length of course varying with the number of presses making up the installation.

This is shown quite plainly in Fig. 3, which also gives a good idea of the valve control stands and the ingot racks. It will be noticed in this view that press No. 1 in the foreground is equipped with two molds whereas the rest of the presses are each equipped with one large mold. A full equipment of both molds and dies are provided, however, for working all of the presses simultaneously on either size of ingot. Other odd sizes are provided for one or two presses where the small tonnage

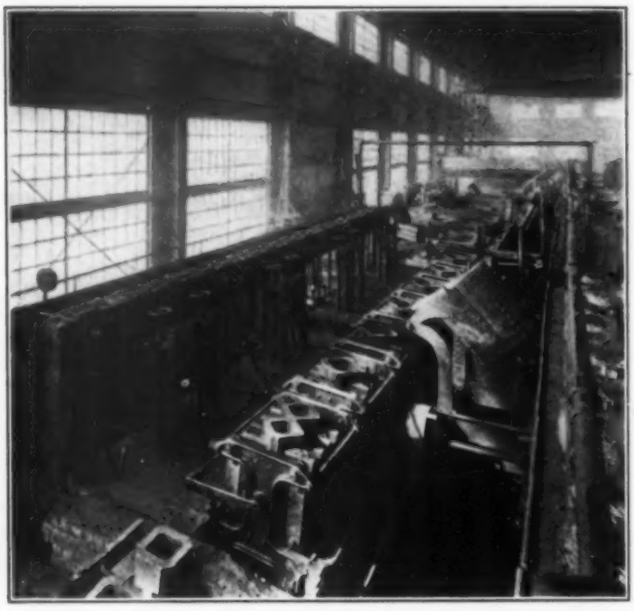


FIG. 3.—WORKING PLATFORM WITH PRESSES

does not warrant equipping eight presses with the special molds and dies.

In ingots up to the sizes mentioned above and also up to and including 3000 lb., split molds are found satisfactory and desirable, as they greatly facilitate the stripping operation and on account of the very short time which the ingots are in the molds there is an entire absence of warping and distorting of the molds commonly met with in split molds where the ingot is allowed to entirely cool in the molds to a point where it usually is stripped. Molds are in operation in Lockport at the present time which have been running eight months night and day and are just beginning to show slight cracks in the side walls of the molds and which are good for another six weeks or two months.

It will be noted by referring to Fig. 1 that the press proper is of a box-like form or design, this being found desirable on account of the great strength for the total weight of the completed press, and for the low cost of machining, aside from making it very rugged and not easily damaged by rough handling. The hydraulic compressing cylinders form one end of the "box" and a heavy steel casting forms the other end, these two members being tied together by cast steel side stress members, interlocking joints being provided, so that the greater the strain between the back head and the rams the more closely do the side members pull in on the cylinders and back head. The tie rods holding all of the press members together have, therefore, only to keep the members in place when there is no load on the rams or when handling the units.

A simple retracting arrangement for the cross head and hydraulic rams is provided which, in the case of the smaller size units, is usually a spiral spring and which, in the larger sizes is a hydraulic cylinder of very small cross section relative to the cross section of the pressing cylinders and which is piped to the high pressure supply without any provision being made for valves or control.

The mechanism for lowering the partly cooled ingots from the molds into the compressing dies consists of a hydraulic cylinder and ram carried on two swinging arms (one on each side of the press), so that it may be brought out of vertical alignment with the dies when desired and leave the pit under the dies absolutely clear and unobstructed. The mechanism for accomplishing this result consists of a small low pressure cylinder usually mounted on the back end of the press and provided with a simple cross arm and connecting rod arrangement controlling the movement of the swinging arms carrying the lowering ram cylinder noted above. The controlling valves and mechanism are extremely simple, all of the movements of the ingot after it leaves the mold being accomplished by one low pressure controlling valve, the handle of which being moved from notch to notch causes each of the parts to function properly and in their proper order. The high-pressure cylinders are controlled by a simple form of stop valve and a simple one-way valve for discharge.

Mounted above the compressing dies is a mold-carrying rack which needs very little explanation, as the drawing Fig. 1 shows quite clearly the principle on which this works. The molds shown here are split molds and in the smaller sizes this mold-carrying rack is operated by hand and in the larger sizes by a small hydraulic cylinder mounted on the side of the press frame and which is not shown in this drawing. Ingots of various cross sections have been operated on by the regular equipment, but the present molds and dies are designed and built for pressing the ingots corner-wise; that is, with one of their cross-section diagonals at right angles and the other normal to the direction of compressing, and ingots of square cross section have been found to work out better not only from the compression standpoint but also for subsequent operations in the mills.

The bottom of the split mold referred to is formed partly by a removable round taper block carried on the lowering ram and so arranged that when the molds are "set up" this lowering ram is in its uppermost position and the taper block forms a "bottom closure" to prevent steel from running through the bottom of the mold. It is found that these blocks or mold bottoms take practically all the wear of the mold, such as the cutting effect of the stream of molten steel when pouring, and

FIG. 4.—VIEW OF POURING

they are practically the only parts that have to be renewed under seven or eight months, and these ordinarily last when running night and day on one 30-pot furnace from two to three months. The regular procedure or operation on ingots with this apparatus is as follows:

The molds (having been previously well smoked without removing from the racks) are locked together by the toggle arrangement shown in the drawings and the lowering plunger

brought to its uppermost position so that the bottom of the mold is closed by the taper block referred to. The controlling valve on the high pressure cylinder is, of course, closed and the discharge valve opened and the dies are thus opened to a predetermined point.

The molds are now poured by any approved pouring device, but at the plant described by a top-poured hydraulic operated ladle, shown in the half-tone, Fig. 4, and after pouring the ingots are allowed to set a pre-determined length of time, depending on the size of the ingot, composition of steel, etc., but in any event just as short a time as is necessary to form a light skin which will not burst open when the ingots are stripped. This time varies from one to five minutes on ingots from 150 to 600 lb. in weight and of various composition. The stripping mechanism is now operated so that the molds occupy the position shown in Fig. 2 (which shows the ingot partly descended into the dies), leaving the ingot supported at the top end by the molds (which are not opened much, if any, at their top ends) and by the tapered block at the bottom end which forms the bottom closure of the mold during the pouring.

The low-pressure controlling valve handle is now moved one notch, causing the ingot to descend into the compressing dies, the speed of this descent being controlled by a stop cock in the discharge line. The lowering cylinder is provided at its lower end with a spring or in some cases with a hydraulic stop so that the ingots are brought to rest very gently and in a position suitable for the pressing dies to operate on them. The high-pressure release valve is now closed and the low-pressure controlling valve handle is moved to the next notch and low-pressure water is thus caused to flow from the low-pressure supply through a high-pressure check valve into the high-pressure compressing cylinders and the compressing dies are thus rapidly moved up to and in contact with the ingots and the clinders filled with water under low pressure, usually 100 to 125 lb. The high-pressure controlling valve is then opened very slightly and compression is commenced. At this point, the ingots are still fluid internally and have not begun to show the slightest sign of pipe or "sinking" in the top end.

The compressing cylinders are allowed to come up very slowly, indeed, so as to just keep the ingots from forming pipe and this is continued until by experience it is known that the ingot is very near the point of setting or becoming solid throughout, when the pressure is increased slightly and a small amount of the last portion of the ingot to cool is squeezed out of the top, this, of course, being the liquated portion mentioned by A. Capron in his very able paper before the British Iron & Steel Institute of 1906 and, as pointed out by Mr. Capron and others, this liquated portion contains practically all the segregation and is decidedly higher in phosphorus, sulphur and other impurities. This liquated portion forms a rough ball-like knob on the top end of the ingot and is practically the only portion of the ingot not suitable for finishing and in weight varies from 2½ to 4 per cent. of the total weight of the ingot.

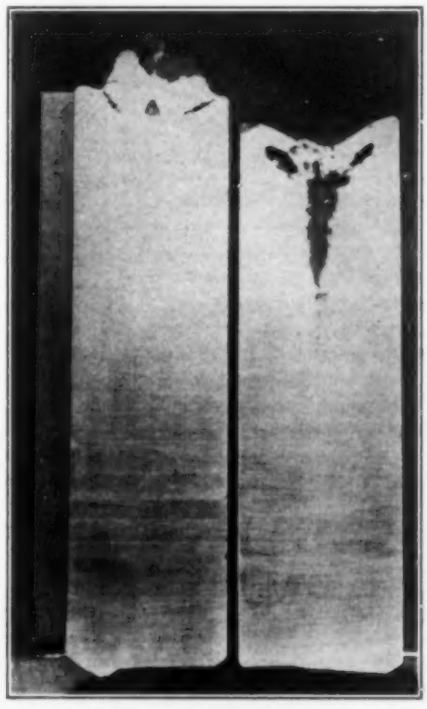
As soon as the compressing dies have a good grip on the ingots so that there is no possible danger of their dropping through into the pit, the low-pressure controlling valve handle is moved to the fourth notch, causing the low-pressure cylinder to move the ingot-lowering cylinder out of vertical alignment with the compressing dies and the controlling valve is then left in this position until compression is completed.

The pressure is kept on the ingot for a considerable time after they have ceased to "rise"; in fact, after they have reached the point where they are considered solid the pressure is quite materially increased and the ingots then receive what is virtually a hydraulic forging treatment which tends to break up the coarse crystals formed in cooling into a fine crystalline structure much resembling an ingot worked under a hammer or forging press.

When the operation of compressing is completed, the high-pressure control valve is closed and the discharge valve opened, when the dies immediately retract and the ingots drop through into the pit, and this may be provided either with a bottom of sand so that the ingots may be given a partial annealing before going to the stock piles, or the ingots may be dropped on to cars or a conveyor. The resulting ingots have the appearance shown in Fig. 5, this being from a 400-lb. ingot split longitudinally, while Fig. 6 is an ingot poured at the same time weighing slightly less on account of its decreased length and not compressed.

There is no dismantling of the presses to discharge the ingots and the operation of setting up ready for another heat takes but a few minutes. In fact, the first of the presses to be poured are quite often set up, that is the molds locked together and the low-pressure valve handle moved to the first notch of its quadrant, thus causing the lowering ram to rise to its uppermost position and the taper block which it carries to close the bottom of the mold, before the last of the series have dropped their ingots and the total operation of setting up eight presses occupies but 10 or 12 minutes, the greater part of which is used in smoking the molds.

One man easily operates eight presses and the presses are so designed that they may take care of from two to three furnaces (in the plant being described these being being 30-pot



FIGS. 5 AND 6.—INGOTS WITH AND WITHOUT COMPRESSION

crucible furnaces), providing all the furnaces are running on the same size of ingots so that it is not necessary to change the molds and dies between the heats, as the presses are amply provided with cooling facilities so that the parts do not become overheated.

It is quite obvious that with the hot ingots in contact with the mold walls only about 1/20th of the time usual where they are allowed to cool in the molds, the latter do not get overheated and no artificial cooling of any kind has been found necessary on the molds. The cross head and, on large presses, the compression dies are provided with water cooling, and the high-pressure cylinders are also piped so that when they are not under actual load low-pressure cooling water may be circulated through them, thus keeping the rams and packing leathers at a reasonable temperature. There has been no trouble whatever experienced with packing leathers, all of these having on an average run ten months, night and day, without renewal.

The pressing dies, as mentioned early in these notes, are of cast steel and in the equipment described there are two grades;

that is, one-half of the dies are of .40 carbon and the remainder .70 carbon steel castings, but up to the present time there is no appreciable difference in their performance, as all of the dies show practically no signs of wear and should last at least one year without replaning, and as the design has made allowance for at least seven or eight replanings, they should last four or five years without renewal.

One point of special advantage in changing from one size ingot to another is the fact that there are absolutely no fastenings of any kind holding the molds or dies to the other mechanism, excepting that the molds are provided with loose links which drop over one of the cross bars in the mold rack and can be readily lifted out by hand or by using a pair of tongs.

The molds are usually lifted out of the rack with the crane in pairs, special hooks being provided for this, and it is no more trouble to lift them out or in the mold racks than lifting them up from one position on the mill floor and setting them down in another. The compression dies are simply lifted in or out of the press frames and gravity alone keeps them in place. The retraction of the movable dies is accomplished by a loose fitting link, one end of which engages a pin in the top end of the movable die, the other end a pin in the top end of the cross head, and this is readily lifted off and on with tongs or by hand.

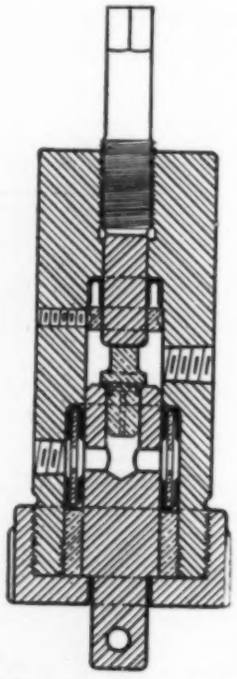


FIG. 7. — HYDRAULIC VALVE

The plant at Lockport is served by a single-acting triplex, high-pressure pump with 1¼-in. rams and 8-in. stroke and driven by a 15-hp. motor, and the low-pressure supply is obtained by a 3½-in. x 4-in. triplex, single acting pump running at 100 lb. pressure and driven by a 3-hp. motor, and as these pumps are only run about one-half hour at each heat, it is obvious that the power consumption is extremely low. Both pumps have a common supply tank and, of course, the discharge from the cylinders is piped back to this tank.

This portion of the plant was so designed that, if found desirable, during the extreme cold weather incurred at Lockport, a solution of alcohol and water could be used to guard against freezing, but so far this has not been found necessary as the radiated heat from the adjacent furnaces has been sufficient to obviate any trouble from freezing.

It may be said in passing that all of the hydraulic valves on the high-pressure side of this system are designed on the lines shown in Fig. 7, so that the valve and valve seats can be removed very readily for repairs without breaking any pipe connections. The time for making a change on any of these valves practically never exceeds 30 seconds, and on a test has been done in 9 seconds, and as the parts are extremely simple to machine, this is one of the least of the troubles in the every day operation of this plant. It has been found desirable to also equip the hydraulic pump which operates at 4500-lb. pressure with valves of this general type, so that there is never any shut-down or stoppage on account of leaky valves.

In a general way, the method is not intended to be a curative one, as tests made in our early experiments proved conclusively that if a pipe in an ingot had once developed and sulphides and oxides formed on the surface of the cavity, it was practically impossible to weld it up or cure it in any way, but the method is preventive and most effectively prevents a pipe forming. Various grades of steel have been operated on that may be made in a crucible or electric furnace, but practically all of the tonnage so far handled is tool steel used in the manufacture of saws and machine knives, this including straight carbon steels of the usual carbon content for the purpose noted, as well as low alloy steels. It has been found, however, that in the case of strictly high-speed and semi-high-speed steels the apparatus must be handled very carefully and the ingots at once annealed after pressing, this owing to the increased density of the already very dense material, owing to compression. Great care must also be taken in re-heating ingots of this type that the heat is brought up slowly and uniformly to prevent the ingots bursting.

The plant as described above has been working night and day for something over a year and at the present time all of the band saw and circular saw steel, excepting the very small circulars, are made from compressed material and equipment is now in process of construction which will enable the Simonds Mfg. Co. to compress every pound of steel made in Lockport.

It has been found that the total cost of operating this plant is less than 3 per cent. of the value of ingots operated on and this will be reduced somewhat when the new equipment is completed, as a greater tonnage of ingots will be handled with no increase in labor cost and a decrease in capital charge, for the reason that interest and depreciation is now taken at 15 per cent. on not only the total cost of the plant as a going proposition, but also on all of the experimental work and expense up to date.

Experiments are also under way for a modification of the device to be used, especially on large ingots in which the split molds are replaced by the usual form of solid tapered mold handled by an ingot stripper of the usual design. The process and apparatus is covered by patents Nos. 922,587 and 926,489 of 1909 and 1,056,101 of 1913, as well as patents in foreign countries, all granted to Mr. L. E. Howard and assigned to the Simonds Mfg. Co.

Iron and Steel Committee of the American Institute of Mining Engineers

The following Iron and Steel Committee has been appointed by the American Institute of Mining Engineers to serve until the next annual meeting: Charles Kirchhoff, chairman; Albert Sauveur, vice-chairman; Herbert M. Boylston, secretary, Abbot Building, Harvard Square, Cambridge, Mass.; John Birkinbine, William H. Blauvelt, James Gayley, Henry D. Hibbard, Henry M. Howe, Robert W. Hunt, J. Esrey Johnson, Jr., William Kelly, Richard Moldenke, Joseph W. Richards, A. A. Stevenson, Felix A. Vogel, Leonard Waldo, William R. Walker, William R. Webster, Frederick W. Wood.

The various interests of the iron and steel industry are authoritatively represented on this committee by producers of raw materials (iron ore, coke and other fuels, refractories, etc.) and of finished materials, by consumers, consulting metallurgists and educators.

The primary duties of the committee are to secure important papers on iron and steel, to promote their discussion, to organize lively and fruitful meetings and otherwise to foster the interests of the large number of members of the Institute connected with the iron and steel industry in its many phases. Its success during the past year has been noteworthy and was highly conspicuous at the meetings in Cleveland and New York.

Since the next meeting of the Institute is to be held in the mining district of Butte, far remote from iron and steel centers, plans are now being made for a meeting in a more accessible place in the latter part of October under the auspices of the Iron and Steel Committee to be devoted to the presentation and discussion of papers relating to iron and steel.

Bureau of Standards' Analyzed Samples of Acid Open-Hearth Steel

The Bureau of Standards, Washington, D. C., has now ready for distribution samples of acid open-hearth steel with 0.8 per cent and 1 per cent carbon, the fee being $2 per bottle holding about 150 grams.

A New Recorder Pen Arm to Facilitate the Changing of Charts

Every user of recorders has found, without doubt, the changing of charts to be a continual source of annoyance as well as time-consuming operation, owing to the obstruction caused by any practically rigid pen arm. The lifting of the pen arm from the chart holder, retaining it in a strained position with one hand, while the chart is changed with the other, without spilling the ink or soiling the chart, requires considerable practice and dexterity.

FIG. 1. — RECORDER PEN ARM

The Schaeffer & Budenberg Manufacturing Company, of Brooklyn, N. Y., have applied for patents on a new recording pen arm to be used exclusively on their Columbia recording gauges, Columbia recording thermometers and Columbia tachometers.

The three elements of the new Columbia pen arm and their respective functions are clearly apparent from Fig. 1, in which the upper part is the pen arm proper, the lower part is the pedestal, so to speak, and between these two parts there is the adjusting screw.

In Fig. 2 the pedestal is directly connected to the recording element of the instrument, the pen arm being placed over this and retained there by its slight resiliency and with the aid of the pin on the adjusting screw.

When the chart is changed, the pen arm is drawn towards the operator, lifted off the pin, and allowed to drop down to the right while the pedestal remains stationary (see Fig. 2). The obstructing pen arm being thus removed, and both hands being free, the chart can be changed and the pen arm placed in its proper position again in an instant. The adjusting screw represents an important feature. A slight manipulation of the thumb adjusts the pen arm whenever necessary.

The Schaeffer & Budenberg Manufacturing Company have just issued a handsome and comprehensive catalogue on their Columbia recording gauges, in which the Columbia pen arm is illustrated and described.

A New Ammeter and Voltmeter

The Keystone Electrical Instrument Company, of Philadelphia, Pa., has been perfecting for the past year a midget ammeter and voltmeter 3 in. in diameter of the highest grade for use on switchboards, automobile dashboards, and for portable service where a small instrument is particularly desirable.

In bringing out these instruments the Keystone Electrical Instrument Company has endeavored to reduce the number of parts required in the standard d'Arsonval system to a minimum. It is a well known fact that the d'Arsonval principle is the most accurate for direct-current measurements, and in order to reduce the cost of these small instruments, and at the same time produce a high-grade accurate instrument much study has been given to this feature.

The adjoining illustration shows the board-type Keystone ammeter, with cover removed, showing the simplcity of construction. A tungsten-steel magnet of unusually large size is used so that permanency can be secured, and to increase the dead-beat operation of the instrument.

This magnet has no special pole pieces, the poles being accurately ground. This does away with the magnetic joint between the magnet and the pole pieces, and also increases the magnetic strength. The bases are of moulded material to insulate the studs carrying the current through the switchboard, or dashboard, and this material is also used so that the magnetic strength may be unaffected. To obtain the greatest strength from the magnets the covers are also formed of brass instead of iron. All holes in the covers and bases are square so there is no possibility of turning of any of the parts when tightened up.

The aluminium coil form, seven thousandths of an inch in

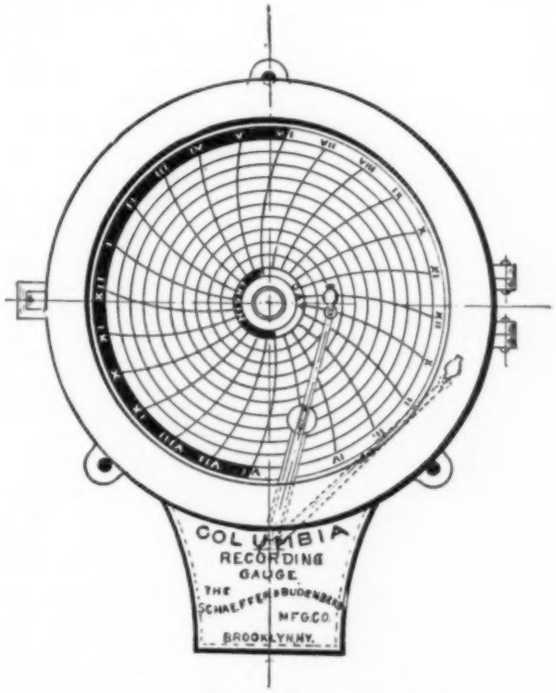
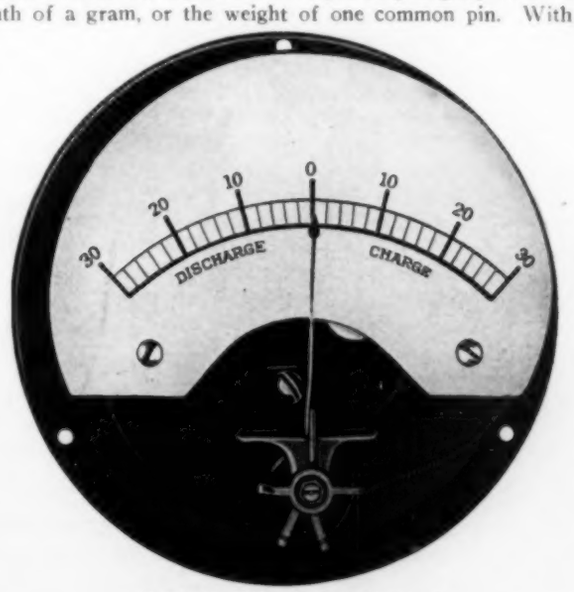


FIG. 2.—PEN ARM ON RECORDER

thickness, on which the fine enameled wire is wound, swings in sapphire jewels between the poles of the magnet. The pointer is of aluminium tubing twelve thousandths of an inch in outside diameter and with a wall one thousandth of an inch thick, and the whole moving element weighs only slightly over one-tenth of a gram, or the weight of one common pin. With a



AMMETER WITH COVER REMOVED

moving element so exceedingly light as this the instrument is absolutely dead beat in operation, and the pointer does not oscillate, although the instrument is subject to severe vibration.

This exceedingly light moving element also has the advantage that there is very little weight whatsoever on the pivots and bearings, assuring long life for the instrument. The scale is white enameled on brass except where the black scales with white letters are preferred.

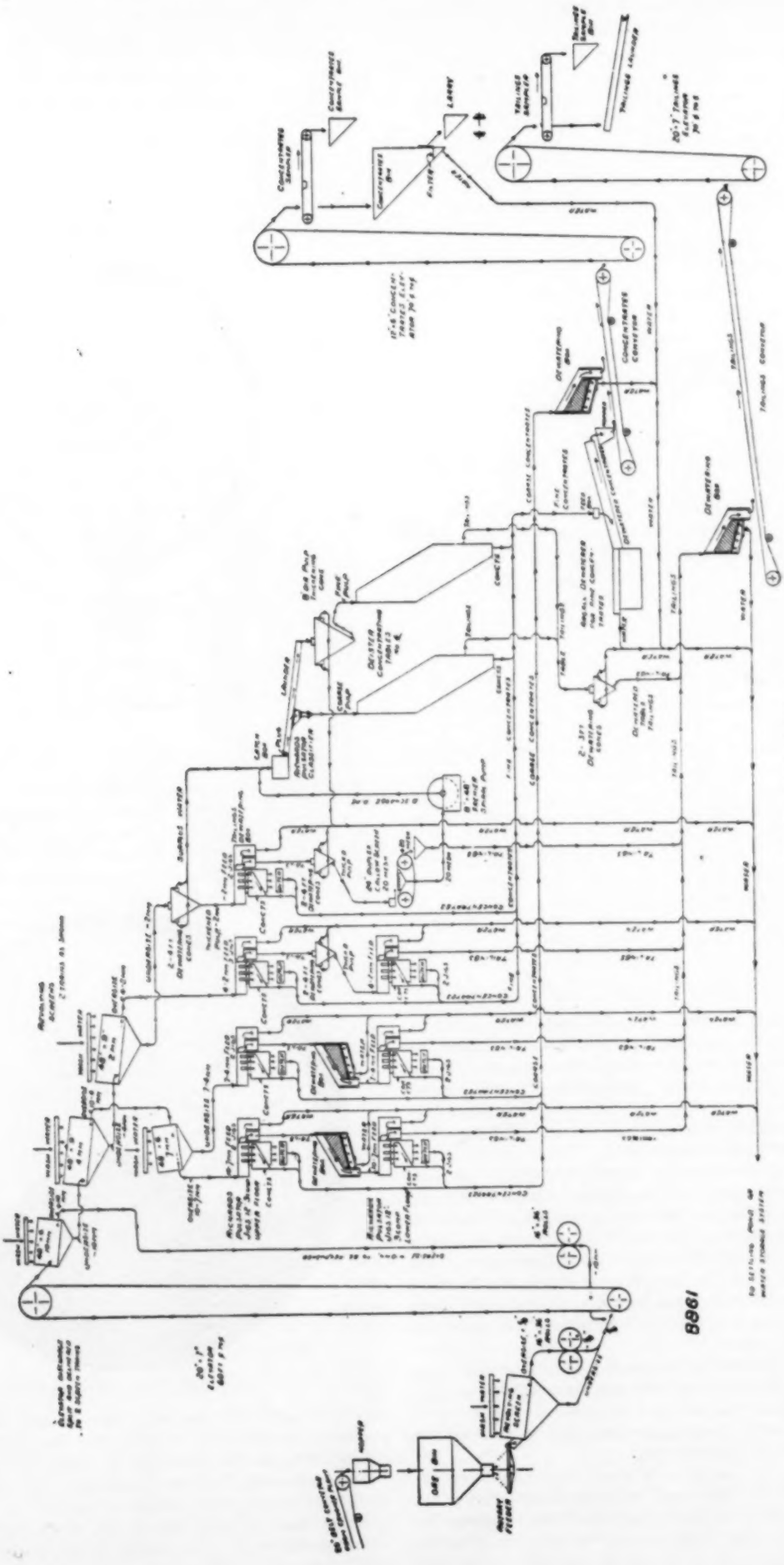


FIG. 2.—FLOW SHEET

Concentrating Low-Grade Iron Ores in Michigan

In iron mining in the Lake Superior District, as in base and precious metal mining in the West, the problem of utilizing low-grade ore is of growing importance. With the gradual exhaustion of the more desirable ore comes the demand for suitable methods of preparing low-grade ore for reduction. There are but three important iron concentrating mills in the Lake Superior region. Two of these, in Minnesota, were described in this journal in November, 1912. At both of these mills the ore is treated without crushing other than that received when it is blasted and steam-shoveled in the open pits. The system

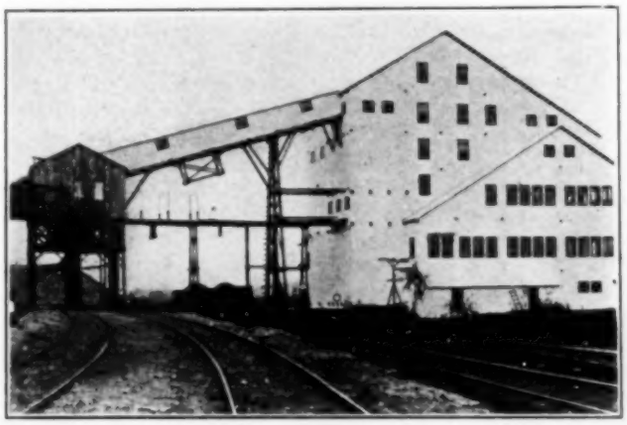


FIG. 1.—IRON-ORE CONCENTRATOR, BOSTON-AMERICAN MINING COMPANY, DIORITE, MICH.

is merely one of washing in trommels and log-washers, with concentration of the finest ore on tables.

Since the erection of these two mills in Minnesota, a third has been built by the Denver Engineering Works Company, Denver, for the American-Boston Mining Company, at Diorite, near Ishpeming, Mich. This mill is designed to treat an ore which requires finer crushing than those of Minnesota, and the feature of the process is the use of jigs, which are not used in the other two mills. Before the American-Boston mill was built, it was necessary to exercise care in the selection of ore shipped from the mine, producing only that which contained a sufficiently high percentage of iron to bear the cost of transportation and reduction. A great deal of ore was found which could not be thus mined and shipped, and it was for the enrichment of this material that the mill was built. The dual result has been a reduction in the cost of mining, and the conversion of a former waste into a valuable product. The ore now being treated is hematite in the form of alternating bands of mineral and gangue.

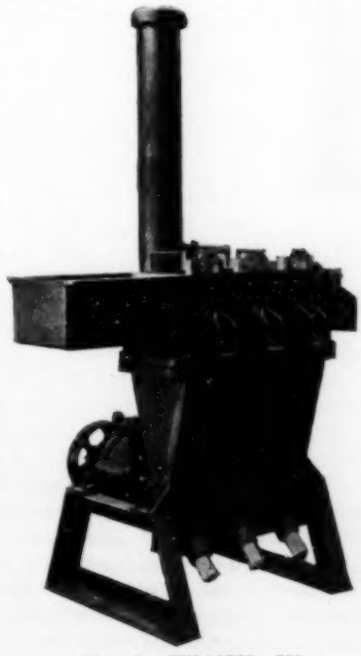


FIG. 3.—PULSATOR JIG

A general view of the mill is shown in Fig. 1, and a flow-sheet is given in Fig. 2 (p. 356). The ore is crushed in gyratories and elevated by belt conveyor to the mill bins. It then passes through revolving screens, ⅝-in. mesh, the oversize from which is crushed in rolls. The screen undersize and the roll product are combined and elevated to two trains of revolving screens which deliver jig feeds of the following limiting sizes: 10 to 7 mm; 7 to 4 mm; 4 to 2 mm; and minus 2 mm. Each of these grades is treated in a separate group of Richards pulsator jigs, 15 of which are suitably arranged on two floors.

The jigs deliver coarse concentrates from side gates above the screens, and fine concentrates from open spigots in the hutches. The tailings from the jigs on the upper floor are dewatered and retreated in jigs on the lower floor. Simple screening has been found an efficient method of treating the tailings from the 2 mm jig, for when this product is thickened and passed over a 20-mesh Callow screen, the oversize can be discharged as tailing. The undersize is classified in a Richards pulsator classifier of the launder type, the spigot discharge concentrated on a Deister table, and the overflow similarly treated after thickening in a Callow cone.

Coarse concentrates are dewatered in a box, and fine concentrates in an Avoca spiral dewatering machine. Both products are delivered to the same belt conveyor with about 15 per cent moisture, and elevated to a filter-bottom concentrates bin. An automatic bucket sampler is placed between the elevator discharge and the bin.

The arrangement for unloading concentrates from the bins to railroad cars can be seen by reference to the photograph of the mill and the flow-sheet. Concentrates can be discharged by gravity from the bins to an electric larry which runs on a track 30 ft. above the ground, delivering the material either to the railroad loading bins or the stock pile.

A point of interest in this mill is the use of the Richards pulsator jig shown in Fig. 3. Despite the fact that the opinion formerly prevailed that these jigs were not adapted to hutch work, the richest and greatest amount of concentrates produced at the American-Boston mill is from the hutch spigots. The success of the jigs is interesting also because the ore cannot be regarded as specially adapted to jigging on account of the production of thin flat scales of mineral in crushing.

The water supply is obtained from a small lake, being pumped to a sump at the mill, whence it is raised to the mill storage tanks by centrifugal pumps. A large part of the water discharged from the mill with the tailings is recovered in a settling pond, the overflow from which gravitates to the mill sump.

The arrangement of the mill is such that most of the operations are automatic, and only four men are required per shift.

Since the mill was put in operation and adjusted, it has been running steadily. Within two weeks of the start it was producing 60 per cent iron concentrates at the rate of seven standard-gage ore cars per day. The present capacity is 500 tons in 24 hours, but space is still available for more jigs, and the management expects to increase the capacity to 900 tons per day. The local manager for the American-Boston company is Mr. J. R. Thompson, who was one of the first to appreciate the possibility of enriching the low-grade iron ore by concentration.

High Vacuum Surface Condensers is the title of Bulletin 106A, recently issued for general distribution by the Wheeler Condenser & Engineering Company, of Carteret, N. J. This bulletin takes up such subjects as the effect of condensing on steam engine and steam turbine economy; the choice of a kind of condenser; the design of high vacuum surface condensers; the influence of steam distribution; the effects of flooding on condenser surface, and explains the advantages of the Wheeler dry tube condenser. The bulletin then discusses the details of construction of Wheeler surface condensers, considering such points as the shape of shell, tube plates, tubes, packing water boxes, etc. Consideration is then given to the subject of air pumps for surface condensers. The Wheeler Condenser & Engineering Company manufactures direct-acting wet air pumps for steam engine service, also the well-known Wheeler-Edwards air pump for high-vacuum work, several types of reciprocating, rotative valve dry vacuum pumps, and also the Wheeler-Turbo air pump for the direct connection to the steam turbines of motors.

The Design, Construction and Uses of Centrifugals

By H. H. Stephens

The Weston principle of supporting centrifugal machines, providing a construction that permits a basket to rotate around its center of gravity rather than its geometrical center, is old, and is admitted by all to be the best present solution we have for handling unequally loaded charges on the centrifugal basket with the minimum amount of wear on the apparatus.

It has been, and is, the ultimate aim of many engineers and operators, to produce a centrifugal machine, for the purging of sugar and like uses, that would be continuous in its operation and thus dispense with the continual starting and stopping; the part of the operation that is most destructive to machine

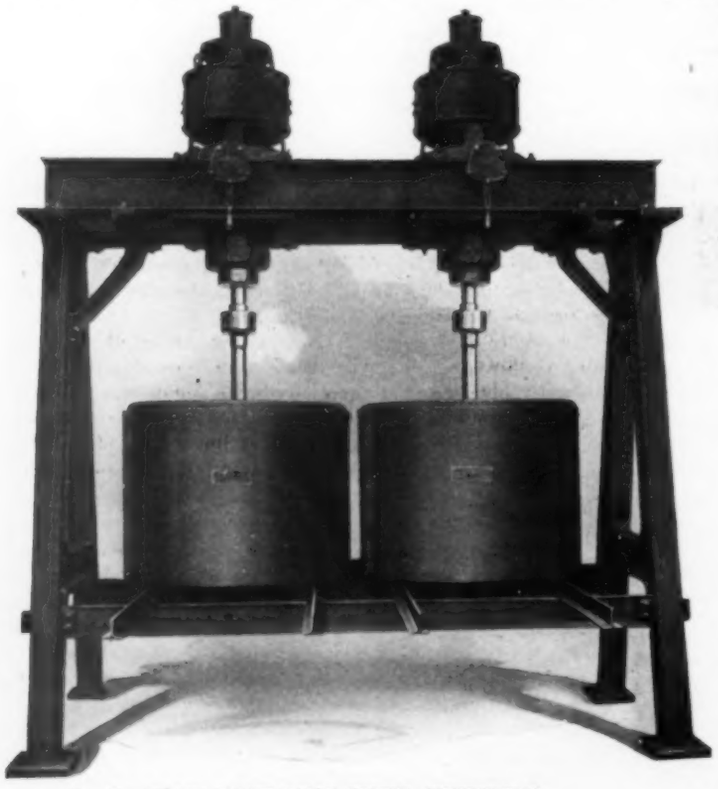


FIG. I.—DIRECT ELECTRICALLY DRIVEN CENTRIFUGAL

and which naturally cuts down output of machine and consumes much more power than if machine runs continuous.

However, the present state of the art does not reveal a practical continuously operating centrifugal, although much thought and study have been given to this. Such a machine would be ideal for some purposes but it is doubtful whether or not a continuous centrifugal could be used to universally supplant the present type of machines. For instance, a continuous machine might be devised to operate satisfactorily on first-grade fine sugars, but it is a serious question as to whether or not the same machine would successfully handle low grades and seconds on account of the entirely different characteristic necessary on the acceleration periods.

Therefore, in view of the absence of such an ideal machine, and moreover, as there is a probability of its not being universal in application it seems that the intermittent operation of the present centrifugals is a necessary evil to which the efforts of all engineers should be directed with a view to lessening the same. The mere fact that such starting and stopping is necessary, not only means a decrease in economy and efficiency, but it also means, which is extremely important to the sugar maker, that the quality and consistency of the discharged sugar absolutely depends on the acceleration periods be absolutely the same.

It thus becomes apparent that, in addition to being the most severe part of the cycle of operation, the intermittent starting imposes upon the designer the necessity of consistent, unvarying performance to maintain a standard of output both in quality and quantity; in fact the behavior of a centrifugal during this period reflects strongly on its design and construction.

Since this phaase of the service is so exceedingly important, it follows that the successful centrifugal must possess the following underlying principles as upon these depend the operation of the entire machine.

1. The operation of starting and stopping must be through one lever rendering the machine as fool-proof as possible.

2. All parts of machine, especially spindle and basket, must be designed amply heavy on account of the severe strains during this operation.

3. The driving motor must be special and designed to handle the severe overloads during the starting period and must be independent of centrifugal.

4. A simple, reliable and rugged starting apparatus that will insure motor never being overloaded beyond a certain predetermined point, no matter how suddenly it is started.

5. A powerful brake, accessible for relining and designed so that the pressure applied is predetermined and not dependent upon the action of the operator.

6. A suspension with proper design of buffer to restrict oscillation and provide a cushion to absorb vibration in bearings and supporting framework.

7. A starting apparatus that must be designed so that variable acceleration can be obtained readily and quickly; and once set must be beyond the immediate control of the operator.

8. A conspicuous absence of all delicate moving parts in machine, motor, or controller.

9. The number of wearing parts and parts requiring lubrication must be reduced to a minimum, and parts such as bearings and buffers must be so placed to be taken out and replaced quickly.

10. The machine must be designed that repairs can be effected in the shortest possible time and avoid any possible tie-up during the running season.

To sum up the above, it becomes apparent that a centrifugal to give maximum output at minimum cost should possess all the essential features thus enumerated.

There are four standerd methods of driving centrifugals in use at the present. Together with their characteristics, they are as follows:

1. Group belted to one driver: Low first cost, low efficiency and output, and high maintenance cost.

2. Individual water driven: High first cost, low efficiency and ouput.

3. Belter to individual motors: Moderate first cost, fair efficiency, expensive belt maintenance and fair output.

4. Direct electric driven: High first cost, maximum output and efficiency, minimum maintenance.

Until recently, it has been the feeling among most engineers that the belted machines as described under Class 1, represented the successful conservative combination of economy and output, but lately, upon fully studying the numerous advantages of the direct electric-driven centrifugals, this attitude has gradually but surely changed in favor of the individual motor, with the result that many modern plants are now employing or specifying exclusively direct motor-driven centrifugals.

The economic centrifugal is never the lowest in initial investment, but it is the machine giving maximum output with minimum power, having fair efficiency, giving a product of consistent quality and being free from serious breakdowns and with low maintenance costs.

The types and uses of centrifugal machines are numerous and steadily increasing. New applications of centrifugal separation

and clarification are being made daily; in fact, the field for its uses seem limitless. A few of the centrifugal processes now in common use are:

Purging.—Granular and crystallized substances, sugar, salt,

FIG. 2—OIL EXTRACTING CHIP CENTRIFUGAL

soda, sulphate of ammonia, brewers' grains, fertilizers, tankage, hides, pelts, and metal turnings.

Hydro-extracting.—Raw stock (cotton, wool, silk, jute, hair, hemp, linen, ramie); textile work (yarns, piece goods, hosiery, felt and hats, beam and spool fabrics and yarns); laundry service, bath robes and bathing suits.

Clarifying.—For filtering and separating various liquors, juices, oils, etc.

Sewage.—For the separation of sludge from fresh sewage and the reduction of moisture therein.

Nitrating.—For all separating processes in connection with nitrating work.

Dyeing.—For dyeing of raw stock, yarns, cops and various forms of textile fabrics, including sulphorous dyes.

Oil and Waste Reclaiming.—For separating and reclaiming oil from wiping waste, machinery wiping towels, rags, etc., for washing and drying waste, towels and other machinery wiping material.

Oil Extracting and Chip Centrifugals.—For recovering oil from automatic machined parts, metal chips, turnings and scrap.

The D'Olier Centrifugal Pump and Machine Company, of Philadelphia, Pa., are the pioneers on the application of the individual electric motor drive for centrifugal apparatus and have been identified with the same for a period of ten years. The cuts shown indicate a few of their standard machines. They also specialize in the design and construction of centrifugal apparatus involving the use of extreme high speeds and special construction.

Cooling Towers.—Natural-draft towers of the Wheeler-Balcke design are described in Bulletin 109, of the Wheeler Condenser & Engineering Company, of Carteret, N. J. These towers are of wood with an improved water distributing system and compact cooling stacks which cools the water on the "drop and film" principle. The walls of the tower are continued above the level of the distributors, so as to form a chimney of some height, which induces a natural draft and draws the air through the tower without any expense of driving fans. The bulletin discusses the theory of cooling, and points out the necessity of scientific design of condensers and cooling towers. It then discusses the economy of the Wheeler-Balcke construction. This bulletin is profusely illustrated with photographs of many interesting types of natural draft towers. Drawings are also shown of typical installations with different types of condensers and towers.

Absorption and Reaction Towers for Chemical Factories

Absorption Towers

Absorption towers, as generally employed in the chemical industry, may be divided into two groups:

A.—For the simple absorption of a gas by a liquid—usually forming thereby a definite chemical compound.

B.—As mixing and reaction towers for gases with *simultaneous* absorption by a liquid.

Under "A" we have towers for the absorption of sulphur dioxide, carbonic acid gas, nitric acid and nitrous fumes (residual gases from works processes and Gay Lussac towers), carbon bisulphide, acetone and the like.

In such cases the chief requirements are that the gases should pass over surfaces uniformly wet with the liquid—that such surfaces should be as large as possible—and that at the same time an eddying motion should be imparted to the gases, as they pass upwards, so that fresh gas particles constantly come in contact with the wet filling material.

Supposing that for such an absorption several towers were arranged in series, it is evident that in the first tower the absorption will proceed more readily than in subsequent towers. It is, therefore, desirable that the filling material for each tower should be suitably chosen, in order to avoid unnecessary expenditure.

The main requirements for good *absorption* are greatest possible surface per cubic foot of filling, good mixing of gas, and the correct proportioning of the ratio between the section of the tower, and the net section free for the passage of the gases—this in order that the gases may not pass too rapidly up the tower, without, however, appreciably affecting the draught.

The intending purchaser has in these days of strenuous competition a large variety of tower packings to select from. The days of coke as a filling material, except in certain very special cases, are numbered, and it has long been established that a small tower with good packing will do the same work as a large coke tower.

Plain acid-proof bricks, prism-shaped bricks, triangular, rhombohedral and trough-shaped bricks, and rings of various kinds, have all been tried, and all suffer from the same defect, namely, that they occupy a large percentage of the volume of the tower, and leave insufficient "absorption space" or "free space" for the gases. Some of these bodies seem to be designed on the principle to take an empty tower, fill it up as much as possible with packing (presumably with the intention of obtaining a maximum of wetted surface) and leave as little room for the gases as possible.

Broadly speaking, it may be said that the better and more efficient the tower filling the greater may be the velocity of the gases. The sectional area of a tower naturally determines the velocity of the gases in the tower, and hence the so-called "free space" or "absorption space" of a filling material has an important bearing on its efficiency. The "free space" is the percentage of the cubic capacity of a tower which remains free for gases.

The great success of the Guttmann hollow balls as a tower packing was due to their very high "free space." Millions of these balls were sold, but they could not come into universal use because of their high cost and because they were unsuitable for large towers and dusty gases.

The latest type of filling material, the Guttmann cells, *are superior even to hollow balls,* and not only in regard to efficiency, but also because the cells are considerably cheaper and have a very high "free space."

As will be seen from the illustrations these cells when built up in a tower form in section a regular honeycomb structure, each four cells enclosing a reaction space corresponding to an additional cell. The whole of the tower is thus symmetrically divided up into a number of equal reaction spaces, and in such a way that both the outer and inner surfaces of the cells are wetted, and must be traversed by the gases, which are ascending and diffusing through the tower filling. "Channeling" or

the formation of separate streams of gases or liquids cannot occur when cells are used, as is often experienced with other forms of filling material.

Fig. 1 shows diagrammatically four cells arranged in the same way as if they were stacked in a tower, the path of the liquor being shown by plain arrows and the probable course of the gases by means of circled arrows.

Slots are made in the top and bottom walls of the cells; the gases entering from below expand in the interior of the cell and pass out through the slots in the top. Each cell is provided at the sides with a number of projections, which rest against corresponding projections on the neighboring cell, and at the same time form the slots for the reaction space formed by four adjacent cells.

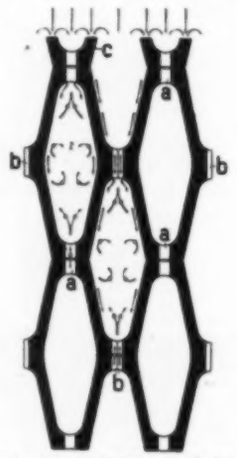


FIG. 1—SYSTEM OF FOUR GUTTMANN CELLS

The gases are efficiently split up and distributed by the slots, and always pass through a narrow opening into a relatively large reaction space; the gases expand into and diffuse throughout the cell before again issuing through a narrow slot; the liquid flowing in the opposite direction, and forming a complete film over the cell surfaces, thus comes into most intimate contact with the gases, and very efficient absorption results. The eddies caused by the alternate expansion and contraction of the gases serve to thoroughly mix the gases and to induce further reaction or absorption.

The side walls of the cells being very steep render it practically impossible for solid matter or impurities to collect on them, while, if necessary, the cells can be readily and quickly flushed down and cleaned. For extremely *dusty gases*—such, for instance, as pass through a Glover tower—the lower third of the tower may be filled with large slabs or bricks in the usual way.

The area of the slots, and thus the area available for the passage of the gases, is so designed that the gases remain for a sufficient length of time in the tower for the reaction to take place, without, however, appreciably affecting the draught.

In order to obtain, as far as possible, a perfectly uniform distribution of liquid, distributing channels are placed on the top layer of cells in the tower, and it will be clear that, given a uniform feeding arrangement for the liquor, the inner and outer surfaces of the cells would be uniformly wetted through the agency of the distributing channels.

The cells give a very stable structure within the tower and they are built up in a regular manner, just like bricks, but without the necessity of paying special attention to their spacing, or to preserving definite intervals between them; the projections at the sides of the cells do this automatically.

The "active surface" of the large cells is 15 sq. ft. per cubic foot and of the small cells 30 sq. ft. per cubic foot, and they are carefully designed and proportioned in every way to give the very best results. Reverting to the question of "free space" we find that both sizes of cells have a free space of 71 per cent.; for all other varieties of filling material the "free space" is at most 40 to 50 per cent.

Let us now take an example:

A tower is required to deal with 1000 cu. ft. of gas per minute, and from experience and research it has been found that for efficient and economical absorption the vertical velocity of the gas up the tower should be 50 ft. per minute. It follows that, when using an inferior filling material and assuming 50 per cent. "free space" (to take the figure most unfavorable for the cells), a tower of $\frac{1000}{50 \times 0.50}$ sq. ft. = 40 sq. ft. sectional area is required, so as not to exceed the desired vertical velocity of the gas. Under precisely the same conditions, and employing cells only $\frac{1000}{50 \times 0.71}$ sq. ft. = 28.2 sq. ft. section are required for the tower. It follows that the area of a tower which is filled with inferior filling material must be greater by at least 42 per cent. than that necessary when using the best filling material, the cells.

Let us now compare the total cost of two towers as above, made of acid-proof bricks and filled to a height of say 24 ft.

	Ordinary Tower.	Cell Tower.
Wetted surface, sq. ft. per cu. ft.	10	15
Free space (maximum) (Usually between 35 and 40% only)	50%	71%
Required area of tower, sq. ft. (To give same free volume)	40	28
Total volume of filling material, cu. ft.	960	672
Total wetted surface in tower, sq. ft.	9600	10,080

The comparative costs under American conditions, exclusive of import duty, may be estimated as follows:

Estimated cost of 1 tower, as above, including foundations and erection, but exclusive of all pottery parts	$3,600	$2,700
Filling material, 960 cu. ft., at $0.70 per cu. ft.	672	
Filling material, 672 cu. ft., at $1.40 per cu. ft.		940
	$4,272	$3,640
Saving		$632

With an equally efficient tower a considerable net cash saving, therefore, results from the use of more expensive cellular filling material. The cell tower is, however, far preferable, because of the saving in ground space and buildings, smaller cost of upkeep of smaller towers and reduced quantity of liquid that has to be circulated (the quantity being proportional to the area of the tower). The last factor in particular is of great importance, as it represents an annual saving which, if capitalized, amounts to a large sum, while in addition, fewer Montejus, etc., may be required.

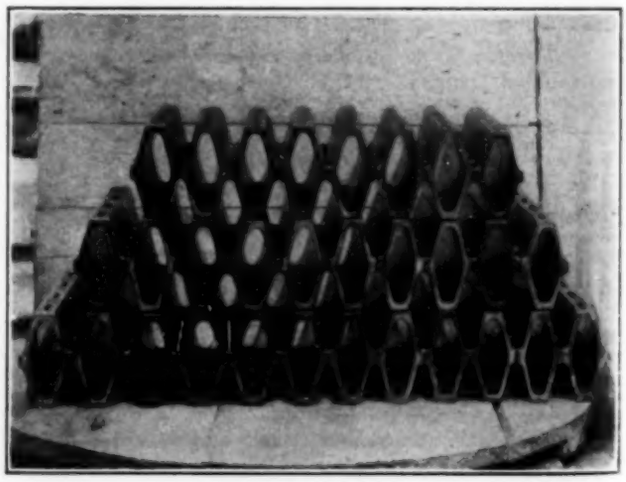


FIG. 2—A SYSTEM OF GUTTMANN CELLS
GREATEST WIDTH, 100 MM.; HEIGHT, 200 MM.; LENGTH, 500 MM.
1000 CELLS PER CUBIC METER

The saving to be expected in the case of towers of other dimensions or with different filling material can be readily determined by a suitable modification of the figures given.

Cells in the "Nitric Acid from Air" Industry and for Artificial Silk, Celluloid and Similar Factories

One of the most important uses to which absorption towers of the above described "B" type are put to is as reaction and absorption towers for these industries.

Such towers must deal with *air* containing about 2 per cent.

NO, and in order to understand what takes place, it is desirable to first examine the nature of the reaction taking place when NO is absorbed by water.

What happens may be seen in the following equations:

$$2\,NO + O_2 = 2\,NO_2$$
$$2\,NO + O = N_2O_2$$
$$2\,NO_2 + H_2O = HNO_3 + HNO_2$$
$$N_2O_3 + H_2O = 2\,HNO_2$$

Nitrous acid is thus produced, which decomposes as follows:

$$3\,HNO_2 = HNO_3 + 2\,NO + H_2O$$

This equation demonstrates that NO is continually regenerated during the process of absorption.

The oxidation of NO to NO_2, which is shown in the equation, is a so-called "time reaction," which is therefore to a great extent independent of the nature of the filling material.

It is specially important that for such uses the tower should be equipped with filling material, which gives not only the necessary active surface and mixing action for proper absorption, but also the greatest possible "free space."

As the oxidation occupies a definite fixed time, so also the required area of the tower, as in the previous example, depends on the "free space" or "absorption space," and the same calculations hold good Large cells are particularly suitable for securing these conditions on account of the low total installation costs of a tower or towers filled with them.

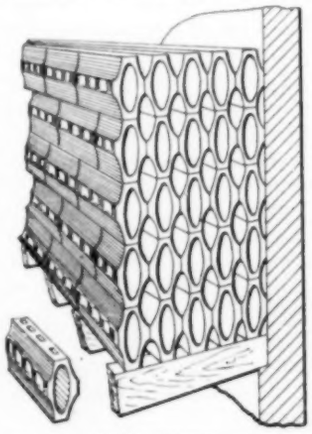


FIG. 3.—ARRANGEMENT OF CELLS IN A TOWER

The "active surface" per cubic foot plays a smaller part in this case than in that first considered, as the chief essential for the good working of such "reaction towers" is a maximum "free space" together with sufficient "active surface."

Similar absorption plants are now being used in the artificial silk industry and in connection with celluloid and similar works. In such cases pure NO gas usually has to be dealt with, which, by oxidation with air, is diluted to a gas containing 5 to 10 per cent. NO.

The cells described in this article are being manufactured by the Deutsche Steinzeugfabrik, of Friedrichsfeld, Germany, their agen in this country being Mr. J. W. Sittig etc.), 5 Beekman Street, New York City.

Bakelite Patent Recognition

As a result of negotiations between the General Bakelite Company and the Condensite Company of America, the suits brought by the former against the latter and its customers for alleged infringement of the bakelite patents, have been withdrawn, and the Condensite company, recognizing the pioneer character of Dr. L. H. Baekeland's work, has acknowledged the validity of the bakelite patents in suit and some others, and will pay substantial royalities thereunder. The General Bakelite company will continue the manufacture of bakelite under its numerous patents, and the Condensite company will manufacture condensite under the Aylsworth patents, as well as the license just granted for such of the Baekeland patents as are broad enough to cover condensite.

This recognition of the force and validity of the principal Baekeland patents by the only other manufacturer of condensation products is a confirmation of the Baekelite company's claims for the broad scope and pioneer character of these patents. There is much that is old in the art of making phenolic condensation products, but Dr. Baekeland was the first to make practical application of what theretofore had been chiefly laboratory experiments.

Production of the Diamond in Electric Furnaces*

By Francis P. Mann

Should the results obtained by a metallurgist of Paris, E. de Boismenu, prove to be all that is claimed for them, his method is likely to work a revolution in the production of the diamond. The inventor has just published the results of his work in a brochure** which appeared at Paris, but the matter has as yet not found its way into the technical press.

Our attention having been called to this publication, it at

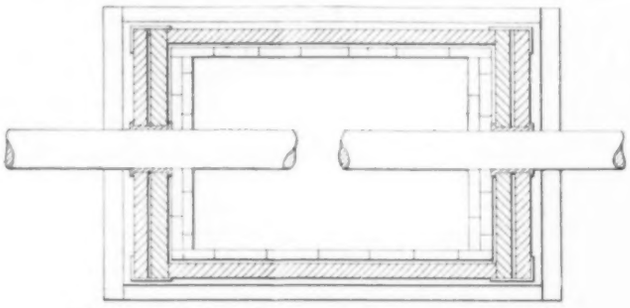


FIG. 1—ELECTRIC FURNACE FOR ARTIFICIAL DIAMONDS

once awakened our interest, especially as we formerly had occasion to observe the work of the late Professor Moissan, of the Paris University, in the formation of the diamond. We accordingly made a visit to the inventor, and he allowed us to inspect a collection of the minute diamond crystals which he obtained, the largest of these having 2.7 mm. (7/64 in.) length. However, as will be further noted, this is believed not to be by any means the possible limit of size, and the inventor is confident of obtaining large crystals of the diamond in a more extensive plant adapted for the purpose.

A comparison with Professor Moissan's process is at once suggested, and this is quite in favor of the new method. It will be remembered that Moissan based his process on the idea of using an extremely high pressure in order to crystallize carbon. Melting iron with an excess of carbon in the electric furnace, he plunges the mass into water so that the surface cools and solidifies around a still liquid inner portion. The violent contraction and resulting pressure on the inside part which is thus obtained acts to bring about a crystallization of carbon in the shape of microscopic diamonds. The largest size Moissan could obtain was a 0.7 mm. (1/32 in.), and there seemed to be no great hope of increasing this size so that the method now has purely a scientific interest.

Quite the contrary is true in the process used by M. de Boismenu. Pressure does not intervene here, and the method consists simply in electrolyzing a fused bath of calcium carbide in an electrolytic furnace by the use of direct current. The heat should last for several hours, and at the end of this time there is found decomposition of the carbide with formation of small crystals of pure carbon. As the size of the crystal depends on the length of the operation, the limit of size cannot be conjectured. It took the inventor a 12 hours' run to obtain his largest size of 2.7 mm. and his experimental plant prevented him from going further, for otherwise he had reason to believe that the size would continue increasing, to what point it is yet unknown.

The plant which he set up in order to prove the value of his theories was located at Paris and was a very primitive one. The main drawback was that the lighting company would not furnish the current except during the day on account of the disturbances to the circuit. He ran a small 50-kw motor which was coupled to a pair of electrolytic generators producing 800 to 1200 amp each at 15 to 40 volts, using these to supply his

*This article is published as an interesting news item, although various points in the process and its description are in need of further explanation.—Editor.

**Fabrication Synthetique du Diamant.

electrolytic furnace. The inventor's results were obtained as far back as 1908, but for a number of reasons they have not been made public until the present time. As it was impossible to make the longer run which is needed to increase the size of the crystals, the plant was stopped during that year. The inventor is endeavoring to obtain the necessary resources for putting up a second and more elaborate plant.

The experimental furnace which he used in the present work was a simple firebrick construction, such as Fig. 1 shows, and had an inner space of 75 cm (30 in.) length by 50 cm. (20 in.) width and the same depth. The bottom was made up of layers of brick with the top part laid out so as to form a V-shaped bed, while the sides had a firebrick lining which could be replaced if need be after the operations. Upon the sole he used a packing of a mixture of powdered lime and carbon containing 80 per cent lime, and as a container for the mass of carbide in fusion he employed a semicircular-section trough made of fused carbide itself, which he found after some trial to be the best. Subsequently he reduced the inside width of the space to 12 cm. by adding firebrick.

As electrodes he used a pair of round carbons of 165 mm. (6½ in.. diameter and 1.50 m. (5 ft.) length. He then proposed to form a bath of melted carbide within the trough and to keep this mass in fusion by the heating effect of its resistance, as is usual in such types of furnace. The two carbons worked within the carbide trough, the positive carbon being fixed and the negative carbon adjustable in the well-known way.

With the present arrangement he was at first successful in producing small crystals of carbon on April 13, 1908, running on this occasion with a heat of six hours' duration. At the start he fed in small particles of carbide around the electrodes, then gradually separating them as the mass heated up, until he finally had 3.5 kg. (8 lb.) of carbide under treatment. The maximum distance between carbons was 24 cm. (9½ in.).

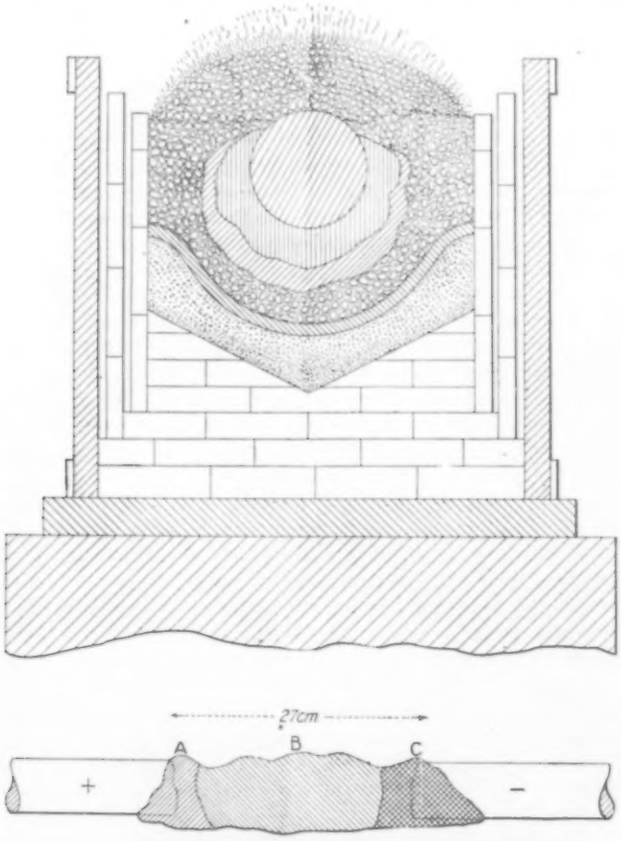


FIG. 2—RESULTS OF EXPERIMENT

During the last three hours of the run the electrical conditions remained rather steady at 34-35 volts and 800 amp.

The current was finally cut off at 4:45 p. m. At 3 o'clock he had fed in the maximum amount of carbide, and then covered the whole with somewhat large pieces of carbide under which the melted mass kept under the action of the current, and upon the whole he placed the above-mentioned lime and carbon mixture, then covered the furnace with a pair of firebrick slabs. The furnace ran in this way until the end of the test.

After allowing to cool off overnight, he opened the furnace and took out the fused mass which adhered to the two carbons. It was seen that a marked electrolysis had taken place. There was, in fact, a striking difference between the negative portion and the rest of the block.

The middle part contained calcium carbide in an apparently unchanged state, while around the positive carbon there was a mass of carbide which appeared to be finer and better crystallized than the ordinary. As concerns the part lying around the negative pole, it appeared to be made up exclusively of carbon in a light and spongy state and black color. This mass was afterwards found to contain flakes of graphite and also minute crystals of pure carbon.

Treating the black mass with water he reduced it to the state of a muddy deposit and then dried the same. He was then able to pick out small diamond crystals, which in this experiment did not reach more than 1 mm. (0.04 in.) in length. These crystals when viewed under the microscope with an enlargement of 20 diameters showed the appearance of the diamond, and beams of light directed upon them at various angles caused them to glow with the remarkably brilliant hues which characterize the diamond. The crystals which the inventor obtained in various experiments were then submitted to two eminent Paris scientists, both members of the Academy, M. Lacroix, professor of mineralogy at the Natural History Museum (Jardin des Plantes), and M. Maquenne, professor of applied chemistry at the College de France. After applying the well-known physical and chemical tests, they both pronounced the specimens to be crystals of pure carbon and consequently diamonds.

Although the crystals obtained in this way are very pure, their form is on the contrary quite irregular and variable. Some of the crystals show two and even three well-defined faces, and others show but one. Still others are rounded off entirely without showing the least face or angle, and the inventor possesses quite a number of specimens of very small size whose nature could not be perceived without the aid of the microscope, as they resemble small grains of transparent silica or melted glass. Some of them have the appearance under the microscope of rounded drops. He considers the shape of these pieces to be the best proof of the authenticity of his specimens, for it would be impossible to form such grains by an artificial process.

We remember, in fact, that Professor Moissan showed us some specimens of his products under the microscope which had the appearance of rounded drops, and he gives some considerations upon this subject in his treatise on the formation of the diamond. The specimens obtained by M. de Boismenu, and which he kindly allowed us to observe, also gave examples of rounded and elongated masses and these appear to be of an analogous character. It would not be possible to procure such minute rounded specimens by breaking up fragments of the diamond, as all who are familiar with the subject will admit at once. We should state that the carbonaceous mass contains quite an amount of even smaller particles down to the minutest grains.

Continuing his work with the electric furnace on about the same lines as described, he made thirteen separate tests during the following two months, in all of which he was successful in producing diamond crystals. What he noticed specially during the experiments was that there was a marked proportion between the length of the operation and the size of the crystals. In fact, the crystals appear to grow in size according to the well-known phenomena of crystallization. This is one of the most important points in favor of his method for he hopes

in the future to secure much larger specimens by applying a longer heat.

It is noticed that by comparing the lengths of operation and size of crystals, the rate of growth is about 0.2 mm. (0.008 in.) per hour. He summarizes these results as follows, showing the lengths of his tests and maximum sizes of crystals:

Length of operation,	6 hour.	Size of crystal,	1.5 mm.
"	9 "	"	2.1 "
"	11 "	"	2.5 "
"	12 "	"	2.7 "

He was unable to run his furnace for more than twelve hours at a time, as we already mentioned, so that nothing leads up to suppose that he had arrived at a limit. Admitting the above rate, and extrapolating a 42-hours' continuous run would give diamonds of 8.7 mm., which is already a large size, and a run of 72 hours would produce the remarkable size of 15 mm. and weighing 60 carats. Naturally this is only a surmise, but there is nothing in the nature of the case to contradict the possibility of such results. What is certain is that he produced crystals of 2.7 mm. on a comparatively short run and with a primitive plant and using ordinary commercial material.

The objection, and apparently a serious one, was made that according to the phenomena of electrolysis, the carbon separated from the calcium should be found not at the negative but at the positive pole. However, the negative side of the bath was found invariably decomposed, and here were seen the crystals and never on the positive side. This anomaly is explained upon observing the working of the furnace, as during the second part of the operation, the negative region constantly gives rise to flames of a bright rose color of characteristic appearance. Calcium in the state of incandescent vapors escaping from the furnace forms these flames, and this element set at liberty at the cathode sets free the carbon with which it was united as calcum carbide. Part of the carbon remains isolated at this pole and is imprisoned and crystallizes in the mass, as the inventor supposes, while the rest of the carbon goes to the positive pole and enriches this part of the bath. The inventor's method is covered by French patent No. 4566, Aug. 24, 1907.

Paris, France.

Condensing Equipment.—The city of Cleveland, Ohio, has awarded a contract to the C. H. Wheeler Manufacturing Company, of Philadelphia, Pa., for surface condensers for the new municipal electric light plant. This plant which will be a model one in every way, will consist for the present, of three 5000-kw Allis-Chalmers turbines with C. H. Wheeler high-efficiency surface condensers having motor-driven Mullan patent vacuum pumps and motor-driven centrifugal circulating and hot-well pumps. The condensers will be installed under rigid efficiency guarantees covering performance under widely varying loads and water temperatures, the normal operation being 28½ in. vacuum, although with cold water and light loads the performance guarantee requires the production of a vacuum within ½ in. of the barometer. The contact was largely awarded on the basis of the extremely low operation cost and low maintenance guarantees made by the C. H. Wheeler Manufacturing Company.

Remedies for Condensation Under Concrete Roofs.—In a recent interview Mr. Leonard C. Wason, president of the Aberthaw Construction Company, Boston, was asked what was a simple method of preventing condensation under a concrete roof of a power house in Boston. At the present time the owners are running a steam pipe under the roof to keep it warm. Mr. Wason stated that, of course, the thing to do is to insulate the roof, and he recommended taking off the gravel and putting down an insulating felt, a number of which are on the market. As an alternative Mr. Wason recommended fastening sheets of cork to the under side of the ceiling. This would cost from 6 cents to 8 cents per square foot.

Refuse Destructor Test

The results of the official tests of the Sterling refuse destructor, installed at Halifax, N. S., by the Griscom-Russell Company, of New York City, have just been made public.

The test was made on March 8, 1913. It lasted three hours. The number of grades was three, the total grate area 75 sq. ft., the Abendroth-Root water-tube boiler heating surface 2034 sq. ft.

Weights:

Total amount refuse consumed		24,072	lb.
Composition House ashes	75%	18,054	"
Wet garbage	16%	3852	"
Rubbish	9%	2166	"
Lb. burned per. sq. ft. grate per hr. grate No. 1		89	"
" " " " 2		73	"
" " " " 3		71.5	"
" " " Average		77.7	"

Water Evaporation:

Temperature feed water	40°
Boiler pressure (gauge)	145 lb. per sq. in.
Factor of evaporation	1.227
Total water evaporated	29,992 lb.
Evaporation from and at 212°	36,800 lb.
Equivalent boiler horsepower	258
Equivalent evaporation from and at 212° per lb. refuse consumed	1.52

Temperatures and Pressures:

Temperature combustion chamber Fahr.	Maximum	1547°
" " "	Minimum	1255°
" " "	Average	1357°
Percentage C.O. 2	Average	9.44
	Maximum	12.5
	Minimum	7.25

Air pressure in ash pit	2.75 in. water gauge
From Regenerator	3.75 in. water gauge
Into Regenerator	4.25 in. water gauge
Temperature outside air	30°
Temperature Air from Regenerator	180°
Temperature Gases into Regenerator	475°
R. P. M. fan	375.
Duration clinkering periods	8 min.
Interval between clinkering periods average	92 min.
Labor cost per ton—city wages	28c.

The combustion of refuse at the test was at the rate of 70 tons in 24 hours exceeding the guaranteed capacity by 40 per cent. The calorific value of the refuse was very low, the analysis of the residues on one test showing 40 per cent of fine dust, 37 per cent of ash, and 23 per cent of clinker.

Personal

Mr. **Charles O. Bannister** was awarded the Consolidated Gold Fields gold medal of the Institution of Mining & Metallurgy, for his paper on the theory of blast-roasting of galena.

Mr. **Sidney Cornell** has severed his connection with the Pittsburgh Crucible Steel Company to assume a position with the Griscom-Russell Company, of New York City, to introduce the various products of this company into the chemical industries.

Dr. **James Douglas** delivered the annual commencement address before the senior class of the Colorado School of Mines, May 23.

Mr. **Robert C. Gemmel,** until recently assistant general manager for the Utah Copper Company, has succeeded Mr. **D. C. Jackling** as general manager. Mr. Jackling retains the position of first vice-president of the company, and has also been appointed managing director.

Dr. **Theodor Goldschmidt,** of the Tin and Chemical Works of Theo. Goldschmidt in Essen-Ruhr, Germany, is making a trip through the West to study latest metallurgical developments.

Mr. **W. J. Hamilton** has succeeded Mr. **A. B. W. Hodges** as general manager of the Cerro de Pasco copper property,

Peru. Mr. Hamilton formerly was smelter superintendent for the same company.

Mr. **Justin H. Haynes** has been retained to design a new cyanide mill for the Junta Consolidated Company, at Telluride, Colo.

Dr. and Mrs. **Paul Heroult** have returned from France on a visit to this country.

Mr. **Louis D. Huntoon** has been appointed eastern representative for the Stearns-Roger Manufacturing Company, of Denver, and will have his office at 115 Broadway, New York.

Mr. **E. W. Lawler,** well known through his long connection with the ball-mill and tube-mill business, has resumed his position with the Abbe Engineering Company, of New York City, with whom he was connected a number of years ago.

Dr. **L. D. Ricketts** is in New York for several weeks.

Mr. **J. B. Risque** has been appointed general manager for the Tennessee Copper Company, with headquarters at Copperhill, Tenn.

Mr. **Guilford D. Scholl,** formerly with the U. S. Metals Refining Company, at Chrome, N. J., has been appointed assistant superintendent of the Electrolytic Refining & Smelting Company, Port Kembla, N. S. W., Australia.

Mr. **E. G. Spilsbury,** of New York, is spending about two months on a professional trip to Colorado and Arizona.

Mr. **Bradley Stoughton,** secretary of the American Institute of Mining Engineers, has been to St. Louis in connection with the establishment of a local section of the Institute at that place.

Mr. **Maximilian Toch,** of New York City, widely known among the chemical fraternity by his extended work in the chemistry of paints, will sail for Europe on May 31 to deliver a lecture before the Paint and Varnish Society of London on Tropical Paints. On July 16, Professor Bogert and Mr. Toch, the American President and Vice-president of the Society of Chemical Industry, will attend the annual meeting of the Society in Liverpool.

Digest of Electrochemical U. S. Patents

PRIOR TO 1903.

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

ORE TREATMENT (*Concluded*).

714,599, November 25, 1902, Sidney Theodore Muffly, of Bowdre, Georgia; assignor of one-half to Runyon Pyatt, of New York, N. Y.

Relates to a process for the separation of metals from their solutions by electrodeposition and refers to the application for his apparatus patent 714,598. The gold-bearing solution, which may be a cyanide, chloride, etc., flows through the cathode of a number of precipitating boxes, in cascade; the precious metal being precipitated upon the cathode, which consists of a cellular casing containing a carbon plate, and a mass of filiform lead and zinc alloy, consisting of 20 parts of lead and 80 parts of zinc. Compressed air is blown through the cathode, called a "mattress-cathode" to assist in the circulation and depolarization. The cathode is surrounded with a fabric cover to prevent loss of any gold particles. The solution leaving the first box flows through a second, and so on; when a box is filled, it is removed and a fresh one inserted at the end of the series, each one being moved up. The filled cellular carbon mattress-cathode containing the gold and any remaining lead-zinc alloy, is incinerated, the ashes collected and carefully smelted to bullion in the usual way.

714,861, December 2, 1902, David H. Browne, of Cleveland, Ohio; assignor to the Canadian Copper Company, of Cleveland, Ohio, a corporation of Ohio.

Relates to an electrolytic process for the separation of copper and nickel from their alloys. The alloy is cast into anodes, and also converted into fragments of powder, the latter is placed in a suitable receptacle wherein it is treated with salt water and chlorine gas, the alloy being dissolved forming cuprous chloride and nickel chloride. This solution is electrolyzed with a copper-nickel alloy anode and a suitable cathode, the liberated chlorin dissolving the anode forming a further quantity of cuprous chloride and nickel chloride; with deposition of all the copper on the cathode, the solution leaving the cell containing the nickel chloride and traces of iron which is precipitated by sodium hydroxide. The nickel chloride solution is now separately electrolyzed, the chlorine liberated at the anode being collected and used to convert the original copper-nickel alloy fragments into their chlorides, and the nickel being electrically deposited.

REFINING.

209,056, October 15, 1878, Nathaniel S. Keith, of Brooklyn, New York.

Relates to refining impure lead by making the same the anode in an electrolyte of lead acetate, lead chloride, or lead nitrate, acidulated with either acetic or hydrochloric acids, to prevent the formation of sub-salts and oxides upon the electrodes. The anodes are enclosed in bags of some textile material, such as cotton, linen, or wool, which collects the insoluble elements, such as gold, silver, antimony, copper, and other constituents of impure pig lead. The cathode consists of copper, brass, lead, carbon, or other suitable material. The lead is deposited in a pure crystalline metallic form, and may be removed periodically and melted.

214,344, April 15, 1879, Emil Andre, of Ehrenbreitstein, Germany, Assignor to Paul Holder, of New York, N. Y.

Relates to refining base metals or alloys and uses an apparatus consisting of an outer tank and two inner concentric cells each having a porous bottom. For refining an alloy of gold, silver, and copper, a saturated solution of copper sulfate, containing from three to five per cent of sulfuric acid is used. The anodes are suspended within the innermost porous cell, the cathodes in the outer tank. At the anode copper and silver go into solution, the gold falling to the bottom of the anode cell. The silver may be precipitated within the cell by protoxid of iron or any other reagent, and the copper solution removed and filtered, or the copper-silver solution may be removed and brought into contact with granulated copper, precipitating metallic silver. The purified copper solution is now returned to the cathode compartment. Within the space between the two concentric porous cells is a constantly flowing diluted acid solution to carry off any anode slime that filters through the anode cell. The exhausted catholyte is returned to the anode compartment.

264,927, September 26, 1882, Henry R. Cassel, of New York N. Y., Assignor to the United States Bullion Refining Company, of same place.

Relates to an apparatus for the electrolytic separation of base bullion, etc., containing gold, silver, and copper. The apparatus consists of a suitable tank containing an electrolyte in which are suspended an anode of the alloy or metal to be refined, and which if granulated, is contained in a suitable bag or box, of fabric or perforated material. Between the anode and cathode is a metallic diaphragm consisting of copper wire-netting, or a bag or box filled with small pieces of copper or other metal, or simply a series of vertically suspended wires. The function of the copper diaphragm is to precipitate the silver dissolved as silver sulphate from the anode; it is collected as metallic silver from the bottom of the vat, leaving the copper sulphate substantially pure. When anodes are used in the shape of plates, etc., a box or other receptacle is hung underneath it to collect any gold slime, etc.

264,928, Sept. 26, 1882, Henry R. Cassel, of New York, N. Y., assignor to the United States Bullion Refining Co.

Relates to a process of refining alloys, base bullion, etc., and consists in enveloping the cathode in a covering of leather, parchment, canvas or other porous material that will permit the current to pass, but not permit the deposition of metal upon the cathode. The anode metals accumulate in the electrolyte.

which, from time to time, is removed and purified; the copper can then be deposited separately.

305,192, Sept. 16, 1884, James S. Howard, of Springfield, Mass., assignor to J. M. Abbott, of Waterbury, Conn.

Relates to an improved solution for refining copper, and separating gold and silver from copper, and copper and other ores. The solution consists of twenty-five parts of potassium bisulphate, two parts of hydrofluoric acid, twenty parts of sulphuric acid, three parts of any of the chemicals containing nitrogen, such as nitrate of soda, potash, etc., and fifty parts of water, and heated to about 175 deg. Fahr. The copper, or ore, is placed in the solution and a plate of carbon in contact with the copper, or the ore. A current due to local action is set up and the copper dissolved. The gold or silver present is caught by a suitable receptacle. The copper may be recovered from the solution by electrolysis, or by tin scrap, iron, etc. Several such arrangements may be connected in series, so that the current generated may be utilized to operate a copper-plating bath to recover some of the copper dissolved.

310,533, Jan. 6, 1885, Bernard Moebius, of Chihuahua, Mexico, assignor of three-eighths to William E. Pope, of Athens, Ga.

Relates to an apparatus for refining silver, and separating it from the gold, platinum, copper, lead, and other metals present. The apparatus consists of a tank or tanks containing anodes and cathodes, and an electrolyte, stirrers to keep the electrolyte in agitation, and sets of reciprocating brushes to constantly remove the anode slime from the anodes, and the deposited silver from the cathodes. A steam pipe runs through the tank whereby the temperature may be regulated. The anodes are suspended in frames which are surrounded with bags to catch the anode slimes; additional bags surround both the enclosed anodes and cathodes. Platinized carbon cathodes are suggested.

Book Reviews

Steel Rails. By **Wm. H. Sellew.** 7¾ x 10¾ inches (20 x 28 cm.), 576 pages, 361 illustrations, 33 folding plates. Price $12.50 net. New York City: D. Van Nostrand Company; London: Constable & Company.

The author is principal assistant engineer of the Michigan Central Railroad. The title of the book lacks definiteness, making it necessary to state that only one-fifth of the work is on the manufacture of rails, and four-fifths on properties and uses.

The first chapter is on the "development of the present section"; it is brief but comprehensive. The second chapter is on the "pressure of the wheel on the rail." This is discussed at length, and in a manner which will greatly interest track engineers. The next chapter, on "supports of the rail," is a hundred-page treatise on "ties," wherein the steel tie is exhaustively studied. Two chapters, totalling over one hundred pages, deal with "stresses in the rail" and "strength of the rail," covering the actual conditions of its use; while the last chapter covers rail specifications.

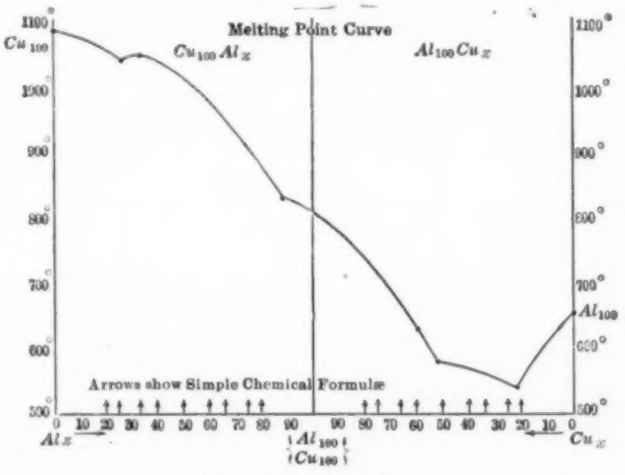
The next to the last chapter, of 135 pages, sets forth the "influence of detail of manufacture," and considering this more at length, because it is the only part of the work dealing with the chemistry or metallurgy of rails, and also because it is the part we feel most competent to pass judgment upon, we have the following to say: 22 pages on the manufacture of pig iron is elementary, at places defective, and not to be taken as other than a superficial sketch of the subject; 30 pages on conversion into steel is likewise fragmentary, but present practice is well stated and beautifully illustrated; 25 pages on "the ingot" is very well condensed, the author frequently putting his finger upon the really important but often overlooked sources of weakness; 43 pages on "influence of mechanical work" are partly very elementary and partly composed of quotations from literature. On the whole, this chapter is unequal in treatment, part being so elementary as to be rudimentary, and part being written as if by an expert for experts. We have a shrewd suspicion that the other parts of the book will meet a similar criticism from competent critics.

The work is beautifully printed and illustrated, heavy calendered paper being used throughout. It has been a work of great labor to accumulate the material presented, and no other book known to the reviewer gives as much reliable information on this subject. We congratulate the author on completing so valuable a contribution to technical literature.

* * *

Atomprozente und Gewichtsprozente: Sowie die Methoden zu Ihrer Gegenseitigen Umwandlung. By Dipl.-Eng. **Fritz Hoffmann.** 19 x 28cm., 20 pages, 18 diagrams and 2 double (superimposed) plates. Price 1.80 Marks. Halle: Wilhelm Knapp.

This monograph is intended to furnish metallographists with a simple, direct method of passing from percentage composition of an alloy by weight to percentage composition in atomic numbers, and *vice versa*. Simple mathematic formulæ are given for passing from percentage on one basis to percentage on the other basis, for systems of two components and of three components. Graphical methods are then shown, whereby given the curve of properties on one basis of percentage composition it can be transformed into a corresponding curve for



ATOM PERCENT DIAGRAM

the other basis. This is a comparatively simple matter in binary systems using the reference-line method; but becomes difficult for ternary systems, using the tri-axial diagram. In the latter case, a double system of reference lines is proposed, one in red ink and on oiled paper, fitting over those in black ink, so that for any spot on the diagram or curves the percentage compositions on both bases can be read off.

The work is very clever, and will help those metallographists who prefer to record or publish their results on the atom per cent basis. Our conviction is that the weight-percent basis is much to be preferred for recording experimental results, and should in no case be omitted. The atom-percents are not suitable for directly recording experimental results, and are not in advantageous form for theoretical discussion. A much more logical diagram for the latter purpose is obtainable by plotting as abscissas from left to right 1 to 100 atoms of A (to 100 of B) and from right to left 1 to 100 atoms of B (to 100 of A). Joining the two diagrams in the middle, which represents A_{100} B_{100}, the two halves cover all possible variations from A_0 B_{100} to A_{100} B_{100} and thence to A_{100} B_0. An example is given in the adjoining diagram.

* * *

The Calorific Power of Gas. By **J. H. Coste.** 12mo (13 x 19.5 cm.), 310 pages, 57 illustrations; price $2.00 net. London: Chas. Griffin & Co., Ltd.

This is a treatise on calorific standards and calorimetry, and concerns itself principally with illuminating gas. It will be useful however, to the producer and user of combustible gas for any chemical or metallurgical purpose. A large amount

of space is given to the official methods prescribed for testing gas, the higher and lower calorific powers, the calibrated and use of still-water and constant-flow calorimeters. While the information is given in a slightly old-fashioned dress, (usually in British thermal units and cubic feet), yet it is almost always reliable and satisfactory, and the work can be recommended as valuable, without any reservations.

* * *

Chemiker-Kalender, 1913. Von **Dr. Rudolph Biedermann.** 2 volumes, 9 x 15 cm., 661 and 402 pages. Price $1.50 in New York. Berlin: Julius Springer.

This well-known chemical year book is better than ever. The more than a thousand pages is most carefully compiled and proof-read, so that errors seem to be practically absent. Where divergent data exists a wise choice is usually made of the most probable values. A characteristically reliable and complete German production; we cannot imagine any technologist to whom it might not be valuable.

* * *

Determinative Mineralogy. By **J. Volney Lewis,** Professor of Mineralogy in Rutgers College. 12mo. (13 x 20 cm.), 151 pages, 68 illustrations; price $1.50. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

This book contains 60 pages of brief description of blowpipe tests and physical properties, including crystallography, followed by 34 double pages of carefully-prepared tables, printed on strong bond paper and neatly inserted. These latter are modelled largely on the Brush-Penfield tables, which in turn were based on the tables of Dr. Roepper, the first professor of mineralogy in Lehigh University.

We find the book very carefully compiled, showing internal evidence of the author's mastery of the smallest details of the subject, such as comes only from a long campaign of laboratory teaching experience. We thoroughly agree with his principle that "chemical composition is the most fundamental property of a mineral," and we even wish that he had used that principle still more extensively in the early stages of his classification.

A few oversights mar the high quality of the tables: *e.g.* the erroneous statements (p. 64) that all minerals of metallic or sub-metallic luster "black or dark-colored streaks," and all of non-metallic luster "light colored or white" streaks; on p. 78 the coat on charcoal is omitted as distinguishing molybdenite from graphite; in many cases round-about net tests are mentioned when the shorter and much more satisfactory blowpipe tests are far preferable—contrary to the author's previously expressed preference for the blowpipe tests wherever applicable; all organic minerals (coals, pitches, etc.) are omitted.

In spite of these and other imperfections, it is a creditable and useful book, which can be made still more so in a revised edition.

* * *

Oil Fuel: Its Supply, Composition and Application. By **Sydney H. North,** revised and enlarged by **Edward Butler.** 12mo (13 x 19.5 cm.), 238 pages, 107 illustrations. Price, $2.00 net. London: Chas. Griffin & Co., Ltd.

While the use of oil as fuel is decreasing in some parts of the world, yet it is increasing in others, such as Texas and California, and this resumé contains therefore information of great value to many industries. The illustrations are almost all working drawings to scale, and show all varieties of oil burners and their attachment to various furnaces. The discussion of chemical composition of fuel oils and the conditions of their combustion is rather brief; the larger part of the book is then taken up with descriptions of burners, and their use for marine, naval, locomotive and automobile purposes, while a rather short chapter is devoted to metallurgical and chemical purposes. The book is, therefore, written more from the mechanical engineer's, or perhaps we might say from the fuel engineer's, standpoint, rather than from that of a chemist or metallurgist; but at any rate it is a useful, practical book.

Explosives: A Synoptic and Critical Treatment of the Literature of the Subject. By Dr. **H. Brunswig.** Translated lated and annotated by Dr. **Chas. E. Munroe** and Dr. **A. L. Kibler,** of George Washington University. 12mo (13 x 21.5 cm.), 350 pages, 45 illustrations. Price $3 net. New York: John Wiley & Sons. London: Chapman & Hall, Limited.

This is another of those works which prove the vitalizing influence of modern science on century-old industries. A great accumulation of experimental material was awaiting the informing touch of physical chemistry, and this science has annexed the whole field as a practical application of the velocities of chemical reactions and chemical equilibria at very high temperatures and pressures.

A perusal of the work is fascinating; it forms one of the finest object lessons in applied science ever written. All of the physics and chemistry of high temperatures and high pressures are put under contribution, and many principles useful in other fields are concretely illustrated. To read it understandingly requires a working knowledge of advanced physics and chemistry, especially of specific heats, latent heats of fusion and vaporization, thermo-chemistry, chemical equilibria and velocities of chemical reactions; but the reader thus equipped will be charmed with the subject.

No one practically manufacturing or testing explosives can afford to be less than master of the contents of this excellent work.

* * *

Accumuladores Eléctricos. Theory, Construction, Installation, Handling, Using and Calculation. By **Gaston Ossa,** Assistant in the Electrochemical Laboratory, University of Chile. 18 x 26 cm., 103 pages, 55 illustrations. Price $1. Santiago de Chile: Sociedad Imprenta y Litografia Universo.

Asked to install a storage battery in the laboratory of the university, the author found the Spanish books on electrotechnology totally lacking in practical directions for this work, and the foreign books were either too voluminous or inaccessible—at least so the author states. Perceiving the need of a short treatise for the use of the Spanish-reading public, this book was compiled. Eight short chapters cover the principles, electrodes, electrolyte, installation, testing, irregularities, manner of using, and calculation of batteries for a given service. The writing seems to be done with full command of the details of the subject, wise selection of the important points, and expressed in clear language (containing, however, interesting deviations from the pure Castilian, characteristic of our Chilean neighbors).

We assure Mr. Ossa that he has most creditably won his spurs as a scientific writer, and wish him still further occupation and success in this line.

* * *

The Principles of Electro-Deposition: A Laboratory Guide to Electroplating. By **Samuel Field.** 12mo (13 x 19 cm.), 383 pages, 121 illustrations. Price 6 shillings ($1.80 net). London and New York: Longmans, Green, & Co.

An extensive but quite elementary work. The fundamental principles are well explained, but practical details are scanty. Many modern ideas or usages are not noticed or regarded. The use of the term coulometer instead of voltameter should be adopted. A kilowatt hour is designed as a B.T.U., which is still a common usage in Great Britain, but should finally be discontinued, as B.T.U. in English literature has three different meanings. It may mean either British Thermal Unit or Board of Trade Unit and as such it may mean either kilowatt hour or kilowatt. Positive and negative poles are marked *+ve* and *—ve*, respectively, instead of simply + and —.

Aside from these minor faults, which give a somewhat old-fashioned impression, the book is carefully written and will serve as a useful introduction to the subject for beginners to read.